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IN COOPERATION WITH THE

DELAWARE AGRICULTURAL EXPERIMENT STATION

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By E. R. SELKREGG,[1] *Entomologist*, and E. H. SIEGLER, *Entomologist, Division of Deciduous Fruit Insects, Bureau of Entomology*

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INTRODUCTION

This bulletin is a report on studies of the codling moth (*Carpocapsa pomonella* L.), in continuation of those under way by the Bureau of Entomology for some years. The plan has been to study the life history and behavior of this important pest in the principal apple-growing regions of the country, especially as representing different climatic conditions. Reports have already been issued on studies made in Michigan, northwestern Pennsylvania, Maine, the middle Allegheny region, Arkansas, New Mexico, Colorado, and the Yakima Valley, Wash. Investigations have been completed and manuscript prepared on the codling moth in northern Georgia. This report deals with the codling moth in the vicinity of Dover, Del., a locality

[1] The work covered by this report was begun in 1919 and carried out by the senior author, assisted by H. J. Dodd. The work was under the general supervision of A. L. Quaintance, in charge of investigations of deciduous fruit insects. The Delaware Agricultural Experiment Station cooperated throughout the course of the work. The resignation from the bureau of the senior author, before the manuscript had been prepared, led to the assignment of the junior author to the preparation of the manuscript from Mr. Selkregg's notes, in which he was assisted by H. Baker.

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fairly representative of the insect in the Middle Atlantic States. A large part of the work was done in a rearing shelter or insectary, in which the conditions approximated natural conditions in the open.

EXPLANATION OF TERMS

For the sake of uniformity the terms employed in this bulletin have been made to conform in meaning with similar terms used in previous life-history studies of the codling moth.

The term "generation" is here used to include all of the consecutive stages of the codling moth throughout the season, starting with the egg and ending with the adult or moth. The first eggs to be laid would thus start the first generation and the resulting larvæ, pupæ, and moths would belong to this same generation. The eggs deposited by the moths of the first generation start the second generation, to which belong the resulting larvæ, pupæ, and moths, and so on.

The term "brood" as used in this bulletin is applied to any stage of the codling moth, which may belong to a specific generation or to an unknown generation. Thus the eggs, larvæ, pupæ, and moths which belong to the first generation are called first-brood eggs, larvæ, pupæ, and moths.

According to the studies in Delaware the larvæ which pass the winter include all of the nontransforming larvæ of the first and second broods and all of the larvæ of the third brood. The specific generation to which each of these individuals belongs can not be determined unless they have been kept separate by rearing methods. The term "generation" can not properly be applied to the various stages of their transformation, and for this reason they are simply called "wintering" or "spring-brood" larvæ, and the pupæ and moths into which they transform are designated "spring-brood" pupæ and moths.

In Dover, Del., and vicinity the larvæ which hatch from the eggs deposited by the second brood of moths do not transform into pupæ and moths the same season as hatched but pass the winter in the larval stage. Hence, this gives what might be termed as a "partial" or "incomplete" third generation. However, the eggs and larvæ are known as third-brood eggs and larvæ.

The "life cycle" of any generation includes the time from the deposition of the egg to the emergence of the moth of the same generation.

The "complete life cycle" of any generation includes the time from the deposition of the egg of one generation to the deposition of the egg of the next generation, and strictly speaking should be applied to the female sex only.

The seasonal-history studies begin with the wintering or spring-brood larvæ which transform to pupæ of the spring brood and from which issue the moths of the spring brood.

The moths of the spring brood deposit the eggs of the first brood, and these eggs, upon hatching, form larvæ of the first brood. Some of these larvæ remain in the larval stage until the following spring, while the remainder transform successively into the pupæ and moths of the first brood.

The moths of the first brood produce the eggs of the second brood, which, after their incubation period, become the larvæ of the second brood. Some of these larvæ do not transform but remain as larvæ

until the following spring, while the remainder pass successively into pupæ and moths of the second brood.

The moths of the second brood deposit the eggs of the third brood, which, upon hatching, form larvæ of the third brood. All of these larvæ pass the winter without transforming.

Wintering larvæ or larvæ of the spring brood (spring-brood larvæ) include all of the nontransforming larvæ of the first and second broods and all of the larvæ of the third brood.

Pupæ of the spring brood (spring-brood pupæ) include all of the pupæ from larvæ of the spring brood.

Moths of the spring brood (spring-brood moths) include all of the moths from pupæ of the spring brood.

The first generation includes: (1) The eggs of the first brood; (2) the larvæ of the first brood, including the transforming first-brood larvæ, and the wintering first-brood larvæ; (3) the pupæ of the first brood; and (4) the moths of the first brood.

The second generation includes: (1) The eggs of the second brood; (2) the larvæ of the second brood, including transforming second-brood larvæ, and wintering second-brood larvæ; (3) the pupæ of the second brood; and (4) the moths of the second brood.

The third generation (not complete in Delaware) includes: (1) The eggs of the third brood; and (2) the larvæ of the third brood, all of which are wintering individuals.

SEASONAL-HISTORY STUDIES OF 1919

The seasonal-history studies of the codling moth were begun at Dover in the spring of 1919 with the collection of overwintering larvæ and the observation of their subsequent pupation. In March 1919, search for overwintering codling-moth larvæ in orchards in this vicinity failed to yield a sufficient number for experimental purposes, but examination of picking baskets in the packing house of a grower at Woodside revealed large numbers of the larvæ in their cocoons, spun between the slats of the baskets. Approximately 2,000 larvæ were collected from these picking baskets from March 20 to 24. A few larvæ were taken from beneath bark scales in the orchards prior to the collections in the packing house. All of these larvæ were allowed to enter pupation sticks for further use in the life-history studies.

It should be explained that each table in this study is a unit in itself. Successive tables are not necessarily continuations of the life history of all of the same individuals given in a previous table. For example, it will be noted that Table 1 is a record of the time of pupation of 405 wintering larvæ, whereas Table 2 is a record of the length of the pupal stage of only 338 of these individuals. Differences of this character may be due to natural or artificial causes, such as death, accidental injury, parasites, the removal of specimens for other purposes, or the accidental escape of moths during examination.

WINTERING LARVÆ

The wintering larvæ consist of all nontransforming larvæ of the first and second broods and all of the larvæ of the third brood. These larvæ pass the winter beneath the loose bark on the trunk and

larger limbs of the tree, or in other similarly protected places on or about the tree. A considerable number of winter cocoons can usually be found also in various cracks and crevices in and about packing houses and storage cellars where harvested fruit or the containers of such fruit have been kept. The larvæ are inactive until spring, when they remodel their cocoons in order to furnish exit tubes which will provide for the safe issuance of the moths.

As previously mentioned, the larvæ which were collected were allowed to enter cocooning racks (sometimes termed pupation sticks) and there form their cocoons. These cocooning racks consist of two

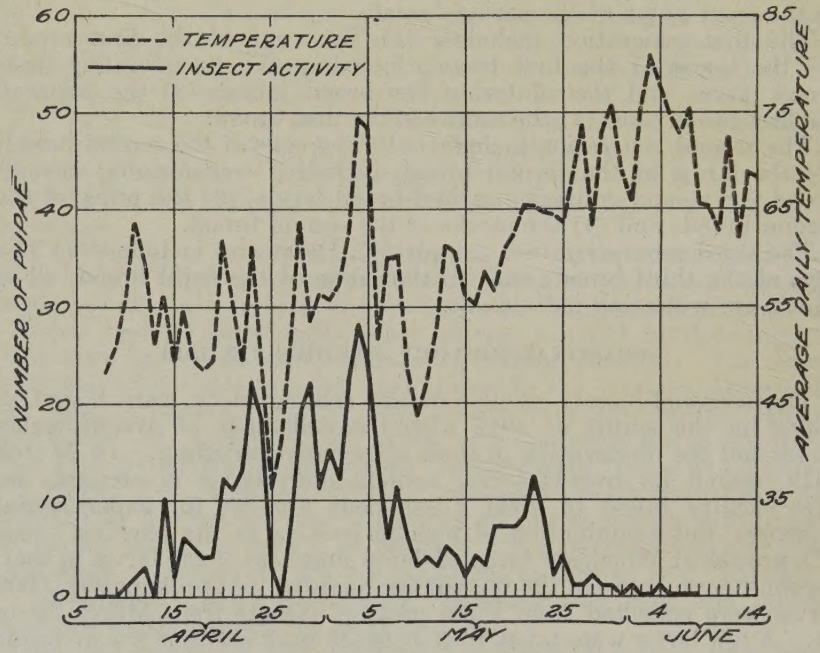

FIG. 1.—Time of pupation of 405 wintering larvæ of the codling moth, Dover, Del., June, 1919

pieces of soft wood, the lower piece being provided with artificial cells or compartments. These were covered with a thin piece of mica or celluloid. The whole apparatus was held together by two metal clamps. This makes it possible to remove the top wooden strip and observe the specimens without actually disturbing them.

PUPÆ OF THE SPRING BROOD

Time of pupation.—Observations of the time of pupation of the wintering larvæ were made daily by an examination of the larvæ within the cocooning racks. The time of pupation of 405 of the wintering larvæ is tabulated in Table 1 and illustrated in Figure 1.

TABLE 1.—*Time of pupation of 405 wintering larvæ of the codling moth, Dover, Del., 1919*

Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ
Apr. 10	1	Apr. 25	3	May 10	3	May 24	2
Apr. 11	2	Apr. 27	8	May 11	4	May 25	4
Apr. 12	3	Apr. 28	19	May 12	3	May 26	1
Apr. 14	10	Apr. 29	22	May 13	5	May 27	1
Apr. 15	2	Apr. 30	11	May 14	4	May 28	2
Apr. 16	6	May 1	15	May 15	2	May 29	1
Apr. 17	5	May 2	12	May 16	4	May 30	1
Apr. 18	4	May 3	22	May 17	3	June 1	1
Apr. 19	4	May 4	28	May 18	7	June 4	1
Apr. 20	12	May 5	24	May 19	7		
Apr. 21	11	May 6	14	May 20	7	Total	405
Apr. 22	13	May 7	6	May 21	8		
Apr. 23	22	May 8	11	May 22	12		
Apr. 24	18	May 9	6	May 23	8		

The first pupation occurred on April 10, while the last larva under observation did not pupate until June 4, approximately eight weeks later. The rate of pupation was more or less irregular, increasing and decreasing every few days with the rise and fall of the temperature. The first real increase in pupation occurred April 14, when 10 larvæ transformed. However, this increase occurred somewhat prematurely, as general pupation did not begin until about a week later, when a marked increase occurred April 20. During the period of approximately two and one-half weeks immediately following—April 20 to May 8, inclusive—271 or 66.91 per cent of the wintering larvæ pupated. However, during this period pupation declined to such an extent that only three individuals transformed on April 25 and none on April 26, at which time there was a marked fall in the temperature. The maximum pupation was reached on May 4 when 28 larvæ transformed, and from this date on pupation gradually diminished.

Length of the pupal stage.—Table 2 records the length of the pupal stage of 338 individual pupæ, the first of which pupated on April 11 and the last on May 17. The pupal period of the individuals that pupated early in the season is considerably longer than that of those which pupated later in the season. This is due to the lower average daily temperature naturally occurring early in the spring. The average length of the pupal stage was found to be 25.13 days, the maximum 39, and the minimum 14.

TABLE 2.—*Length of the pupal stage of 338 pupæ of the spring brood of codling moth, Dover, Del., 1919*

Date of pupation	Number of individuals	Length of the pupal stage in specified days																							
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	39
Apr. 11	1																		1							
Apr. 12	2																		1					1		
Apr. 14	9																						8	1		
Apr. 15	2																						2			
Apr. 16	5																					4	1			
Apr. 17	5																				2	2			1	
Apr. 18	2																				2					
Apr. 19	2																		1		1					
Apr. 20	10																		2	5	3					
Apr. 21	11																1	1	7	2						
Apr. 22	13														1			9	3							
Apr. 23	18																3	13	2							
Apr. 24	17															4	6	5	1	1						
Apr. 25	3															1	1	1								

TABLE 2.—*Length of the pupal stage of 338 pupæ of the spring brood of codling moth, Dover, Del., 1919*—Continued

Date of pupation	Number of individuals	Length of the pupal stage in specified days																							
		14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	39
Apr. 27	7													1	3	3										
Apr. 28	15													7	7	1										
Apr. 29	16												1	9	5	1										
Apr. 30	9												4	2	1	1										1
May 1	13									2			4	5	2											
May 2	10										1	1	6	2												
May 3	22								1		2	8	10	1												
May 4	25						1				2	6	13	1	1	1										
May 5	20							1	1	1		6	8	1	2											
May 6	12										2	6	4													
May 7	4										1	3														
May 8	9					1					2	6														
May 9	4										4															
May 10	3									3																
May 11	3								3																	
May 12	2							1	1																	
May 13	5						1	4																		
May 14	3						3																			
May 15	1						1																			
May 16	3					3																				
May 17	4				4																					
May 18	6			4	1		1																			
May 19	7		3	4																						
May 20	6		3	3																						
May 21	7		6	1																						
May 22	10	1	8	1																						
May 23	5	1	3	1																						
May 24	1		1																							
May 25	4	1	1	2																						
May 26	1	1																								
May 27	1		1																							
Total	338	4	26	16	5	4	7	6	6	6	14	36	50	29	22	12	11	29	18	8	8	6	11	2	1	1

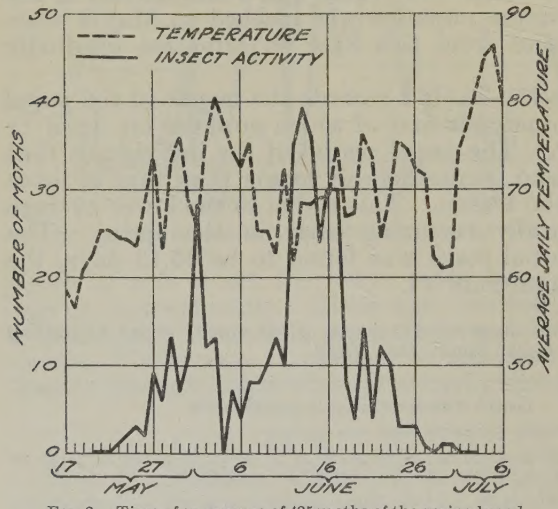

FIG. 2.—Time of emergence of 425 moths of the spring brood of the codling moth, Dover, Del., 1919

MOTHS OF THE SPRING BROOD

Time of emergence.—The time of emergence of 425 moths of the spring brood is recorded in Table 3 and shown in graphic form in Figure 2. The first moth issued May 23 and the last June 30, a period of approximately five weeks. In the course of emergence there were two periods of increased emergence of moths, one from May 29 to June 3, inclusive, and the other, which was the main period of emergence, from June 9 to June 17, inclusive. The maximum emergence of 39 was reached on June 13, followed by a slight decrease and later a more rapid one as the period for issuance of the moths drew to a close. Weather conditions had a part in creating the period of decreased emergence of June 4 to 8, inclusive. The average daily tempera-

ture (fig. 2) declined gradually from June 4 to June 10, inclusive, while at the same time, in the period from June 5 to 12, inclusive, the weather was either cloudy, showery, or rainy.

TABLE 3.—*Time of emergence of 425 moths of the spring brood of the codling moth, Dover, Del., 1919*

Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths
May 23	1	June 2	12	June 13	39	June 23	10
May 24	2	June 3	13	June 14	36	June 24	3
May 25	3	June 5	7	June 15	24	June 25	3
May 26	2	June 6	4	June 16	30	June 26	3
May 27	9	June 7	8	June 17	30	June 27	1
May 28	6	June 8	8	June 18	8	June 29	1
May 29	13	June 9	10	June 19	4	June 30	1
May 30	7	June 10	13	June 20	14		
May 31	11	June 11	10	June 21	4	Total	425
June 1	28	June 12	35	June 22	12		

TABLE 4.—*Oviposition by 976 moths of the spring brood of codling moth in rearing cages, Dover, Del., 1919*

Cage No.	Number of moths	Sex		Date of—			Total number of eggs deposited	Number of days—		
		Male	Female	Emergence	First oviposition	Last oviposition		Before oviposition	From first to last oviposition	From emergence to last oviposition
1	6	5	1	May 17			0			
2	6	3	3	May 18	May 22	May 27	5	4	6	9
3	27	14	13	May 19	May 25	May 30	83	6	6	11
4	37	19	18	May 20	May 26	June 2	102	6	8	13
5	27	14	13	May 21	do	June 3	288	5	9	13
6	26	14	12	do	do	May 31	241	5	6	10
7	37	19	18	May 22	May 25	do	224	3	7	9
8	36	18	18	do	do	June 2	144	3	9	11
9	28	13	15	May 23	May 27	June 5	116	4	10	13
10	29	14	15	do	do	June 4	150	4	9	12
11	28	14	14	do	May 26	May 30	69	3	5	7
12	28	13	15	do	do	June 3	575	3	9	11
13	28	14	14	do	May 27	June 1	81	4	6	9
14	29	16	13	May 24	May 28	June 3	240	4	7	10
15	28	15	13	do	May 27	June 4	323	3	9	11
16	30	16	14	do	do	June 3	322	3	8	10
17	30	12	18	May 25	May 28	June 1	124	3	5	7
18	32	13	19	do	May 27	June 6	454	2	11	12
19	30	12	18	do	May 28	June 2	243	3	6	8
20	32	14	18	May 26	May 29	June 4	325	3	7	9
21	31	14	17	do	do	do	523	3	7	9
22	31	14	17	do	do	do	328	3	7	9
23	32	12	20	May 27	do	do	258	2	7	8
24	32	13	19	do	June 2	do	30	6	3	8
25	32	12	20	do	May 29	June 7	196	2	10	11
26	36	18	18	May 28	May 30	do	162	2	9	10
27	36	18	18	do	do	June 6	248	2	8	9
28	36	18	18	do	do	June 4	236	2	6	7
29	29	14	15	May 29	May 31	June 6	37	2	7	8
30	34	15	19	do	do	do	188	2	7	8
31	36	20	16	do	do	do	172	2	7	8
32	35	15	20	do	do	do	354	2	7	8
33	34	12	22	May 30	do	do	194	1	7	7
34	35	12	23	do	June 2	do	87	3	5	7
35	33	11	22	do	June 1	June 7	50	2	7	8
36	35	12	23	do	do	June 4	181	2	4	5
37	34	11	23	May 31	June 2	June 8	374	2	7	8
38	35	11	24	do	do	June 7	209	2	6	7
39	35	11	24	do	June 1	June 9	200	1	9	9
40	33	10	23	do	June 2	June 8	164	2	7	8
41	40	17	23	June 1	June 3	June 13	375	2	11	12
42	40	17	23	do	do	June 6	120	2	4	5
43	36	13	23	do	do	June 7	236	2	5	6

TABLE 4.—*Oviposition by 976 moths of the spring brood of codling moth in rearing cages, Dover, Del., 1919*—Continued

Cage No.	Number of moths	Sex		Date of—			Total number of eggs deposited	Number of days—		
		Male	Female	Emergence	First oviposition	Last oviposition		Before oviposition	From first to last oviposition	From emergence to last oviposition
44	22	9	13	June 2	June 4	June 9	279	2	6	7
45	22	9	13	...do...	...do...	June 8	66	2	5	6
46	37	12	25	June 3	June 7	June 12	214	4	6	9
47	29	11	18	...do...	June 5	June 15	153	2	11	12
48	27	7	20	June 4	...do...	June 17	293	1	13	13
49	30	9	21	...do...	June 7	June 13	176	3	7	9
50	39	11	28	June 5	...do...	June 19	401	2	13	14
51	38	11	27	...do...	June 6	June 17	442	1	12	12
52	36	12	24	June 6	June 7	June 19	307	1	13	13
53	20	7	13	June 7	June 9	June 25	389	2	17	18
54	15	2	13	June 8	June 16	June 21	29	8	6	13
55	13	4	9	June 10	June 14	June 19	89	4	6	9
Total	1,672	696	976				11,869			
Average								2.85	7.69	9.54

Oviposition by moths of the spring brood.—In Table 4 are recorded the observations of the oviposition of 976 moths which were confined with 696 male moths in 55 cages. The data of this table may be summarized as follows: The average number of days before oviposition was 2.85, the maximum was 8, and the minimum was 1; the average number of days of oviposition was 7.69, the maximum was 17, and the minimum was 3; the average number of days from date of emergence to last oviposition was 9.54, the maximum was 18, and the minimum was 5.

Number of eggs per moth.—The average number of eggs deposited by moths of the spring brood was 12.16. This number was determined by dividing 11,869, the total number of eggs deposited, by 976, the total number of female moths caged, as shown by the data included in Table 4.

Length of life of moths.—The dead moths in the oviposition cages were removed daily, their sex determined, and the length of their life computed. The results of the observations of 607 male and 879 female moths, or a total of 1,486 moths, are given in Table 5. This table shows that the average length of life of the male moths was 8.27 days and that of the female moths was 8.51 days. The maximum and minimum length of life of both the male and female moths in this case proved to be the same, the maximum being 22 days and the minimum 1 day.

TABLE 5.—*Length of life of 607 male and 879 female moths of the spring brood of codling moth in captivity, Dover, Del., 1919*

Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths
Days			*Days*			*Days*		
1	8	3	9	74	126	17	3	2
2	7	7	10	60	86	18	1	0
3	13	12	11	52	74	19	2	2
4	15	21	12	29	51	20	0	0
5	44	69	13	15	31	21	1	1
6	65	96	14	11	14	22	1	3
7	94	119	15	6	13			
8	105	146	16	1	3	Total	607	879

THE FIRST GENERATION

EGGS OF THE FIRST BROOD

Time of egg deposition.—The first eggs of this brood were deposited on May 25, and, as shown in Table 6, deposition of eggs continued up to and including June 24. During this period not a day passed without deposition, as will be noted by an examination of Figure 3. The maximum number of eggs deposited in any one day was 1,453 on June 3, which date, as can be observed in Figure 3, was the day of the highest average daily temperature during the period of egg deposition.

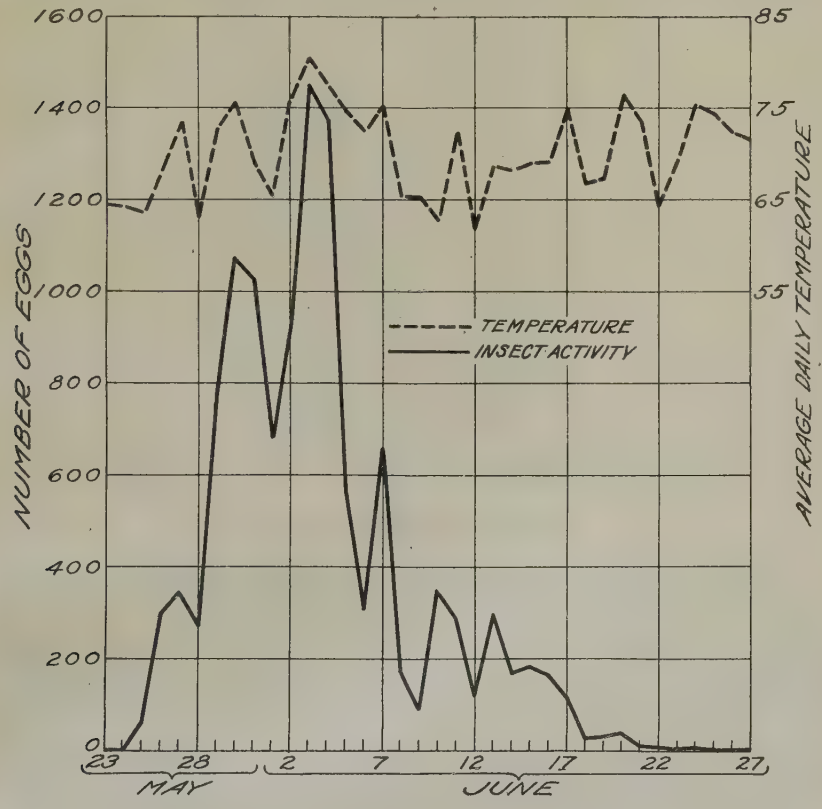

FIG. 3.—Time of deposition of 11,915 eggs of the first brood of codling moth, Dover, Del., 1919

Length of incubation.—The length of the incubation period is given in Table 6. The average number of days from the date of deposition until the appearance of the red ring was 4.55, the maximum 6, and the minimum 3; the average number of days from the date of deposition to the black-spot stage was 5.55, the maximum 7, and the minimum 4; the average incubation period was 6.64 days, the maximum 8, and the minimum 5.

TABLE 6.—*Time of deposition, length of incubation, and time of hatching of 11,915 eggs of the first brood of codling moth, Dover, Del., 1919*

Observation No.	Number of eggs	Date—				Appearance of—		Incubation period
		Deposited	Red ring appeared	Black spot appeared	Hatched	Red ring	Black spot	
						Days	*Days*	*Days*
1	61	May 25	May 30	May 31	June 1	5	6	7
2	298	May 26	...do...	...do...	June 2	4	5	7
3	343	May 27	June 1	June 2	June 3	5	6	7
4	271	May 28	...do...	...do...	...do...	4	5	6
5	781	May 29	June 2	June 3	June 4	4	5	6
6	1,076	May 30	June 3	June 4	June 5	4	5	6
7	1,022	May 31	June 4	June 5	June 6	4	5	6
8	681	June 1	June 5	June 6	June 7	4	5	6
9	938	June 2	June 6	June 7	June 8	4	5	6
10	1,453	June 3	June 7	June 8	June 9	4	5	6
11	1,373	June 4	June 9	June 10	June 11	5	6	7
12	566	June 5	June 10	June 11	June 12	5	6	7
13	313	June 6	June 11	June 12	June 13	5	6	7
14	659	June 7	June 12	June 13	June 15	5	6	8
15	175	June 8	June 14	June 15	June 16	6	7	8
16	91	June 9	June 15	June 16	June 17	6	7	8
17	349	June 10	June 16	June 17	June 18	6	7	8
18	291	June 11	June 17	June 18	June 19	6	7	8
19	122	June 12	June 18	June 19	June 20	6	7	8
20	298	June 13	June 19	June 20	June 21	6	7	8
21	170	June 14	...do...	...do...	...do...	5	6	7
22	181	June 15	June 20	June 21	June 22	5	6	7
23	166	June 16	June 21	June 22	June 23	5	6	7
24	118	June 17	June 22	June 23	June 24	5	6	7
25	28	June 18	...do...	...do...	June 25	4	5	7
26	31	June 19	June 23	June 24	June 26	4	5	7
27	40	June 20	June 24	June 25	June 27	4	5	7
28	9	June 21	June 25	June 26	...do...	4	5	6
29	5	June 22	...do...	...do...	...do...	3	4	5
30	2	June 23	June 26	June 28	June 30	3	5	7
31	4	June 24	June 27	June 30	July 1	3	6	7
Total	11,915	Average				4.55	5.55	6.64

LARVÆ OF THE FIRST BROOD

Time of hatching.—Eggs of the first brood commenced to hatch on June 1 and continued to hatch until July 1, as given in the hatching data in Table 6 and shown in graphic form in Figure 4. The eggs hatched in large numbers from June 4 to June 11, inclusive, except for June 10, on which date no eggs were recorded as hatching. The eggs hatched in maximum numbers on June 9, when 1,453 hatched. This was just six days after the time when the greatest number of eggs was deposited and eight days after the appearance of the first larva. The first larva of this brood was noted in the field on June 2, when a small individual was found feeding in the side of an apple.

Length of the feeding period, stock-jar method.—The length of the feeding period of 852 larvæ of the first brood (both transforming and nontransforming), according to the stock-jar method,[2] is given in Table 7. The first larva entered the fruit June 2 and the last June 26. The average length of the feeding period was 21.21 days, with a maximum of 47 and a minimum of 9.

[2] The stock-jar method is the method of determining the length of feeding period of larvæ in apples placed in glass battery jars.

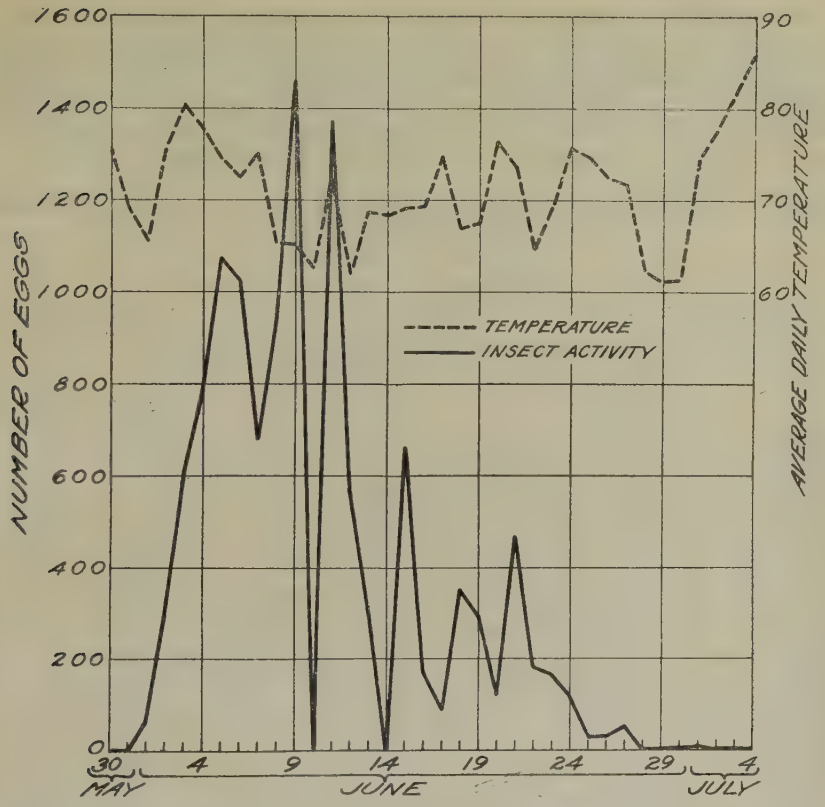

FIG. 4.—Time of hatching of 11,915 eggs of the first brood of the codling moth, Dover, Del., 1919

TABLE 7.—*Length of feeding period of 852 larvæ of the first brood of codling moth, stock-jar feeding method, Dover, Del., 1919*

Date of entering fruit	Number of individuals	Length of feeding period in specified days																																				
		9	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	40	41	44	45	47
June 2	19									2	1	4		3	4	1	3	1									2										
June 4	13										1	1	2		2		2	3																		
June 5	73									1	5	5	10	10	11	7	13	3	2	1		1	2				1							1		
June 6	56										2		3	5	8	9	4	3	3	1	3	3			1	3		1	1	1	1	2	1	1
June 7	20										2	8		2		1	2		1	1	1	1								1					
June 8	22				1				2	1	6	1	7	1								1	1		1										
June 9	151								4	7	17	12	11	21	25	19	5	12	6	2		3	2	1		2	1		1						
June 11	91							2	5	5	8	11	8	15	5	13	6	2		3		2	2	1		1	2								
June 12	31						2	1	2	8	4		2	4	1		4			1	2														
June 13	28						2	2	1	4	4	3	4	3	1		4																		
June 15	23								3	7	3	2	2	1		1		3	1																
June 16	30				4	1	3	2	8	2	6		2	1															1						
June 17	38			2		4	2	7	7	8	2		2			1	1											2						
June 18	64			2	4	9	5	7	8	12		2	6	4		2								3										
June 19	44						2	9	11	8	5	7	1	1																					
June 20	37			1	5	6	7	5	7	2		2						1						1											
June 21	44					2	5		10	5	5	2	5	1	3		4			2														
June 22	22			1		1	3	3	1	7	1		3			2																		
June 23	17					3	3		2		1	4		1				2												1					
June 24	23	2	1		2	2	2	2	1	4			3		1		1			2														
June 25	2						2																												
June 26	4					1		3																											
Total	852	2	1	6	16	29	38	43	72	82	64	60	70	71	57	60	45	42	16	16	5	10	10	8	1	4	9	2	3	2	2	1	3	1	1

Length of the cocooning period.—The cocooning period is here considered as extending from the time that the transforming larva leaves the fruit until it has pupated. The data in Table 8, therefore, apply to 175 transforming larvæ of the first brood, which left the fruit from June 20 to July 19. The average length of the cocooning period was 6.34 days, the maximum 22 days, and the minimum 2 days.

TABLE 8.—*Length of cocooning period of 175 transforming larvæ of the first brood of the codling moth, Dover, Del., 1919*

Larvæ left fruit	Number of individuals	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation																	Average	Maximum	Minimum
		2	3	4	5	6	7	8	9	10	11	12	14	15	16	17	19	20	22			
																				Days	*Days*	*Days*
June 20	1			1																4.00	4	4
June 21	3			1			2													6.00	7	4
June 22	2									1	1									10.50	11	10
June 24	5	1	3				1													3.60	7	2
June 25	5		1			3	1													5.60	7	3
June 26	8					4	3		1											6.75	9	6
June 27	17		1		2	10	1			1								1	1	7.59	20	3
June 28	23			1	13	2	2		1	1	1			1		1				6.83	17	4
June 29	19		1	5	2	5	1	1	1	1					2					6.79	16	3
June 30	17			8	5	1	1						1					1		6.12	20	4
July 1	29		7	9	2	4	1	1	1	1	1	1		1						5.62	15	3
July 2	12		5	2	2	1	2													4.42	7	3
July 3	12			2	6	3		1												5.33	8	4
July 4	4				1			2											1	10.75	22	5
July 5	2		1			1														4.50	6	3
July 6	5						2	2						1						9.00	15	7
July 7	3			1				1						1						9.00	15	4
July 8	1										1									11.00	11	11
July 9	1					1														6.00	6	6
July 11	2			1			1													5.50	7	4
July 13	1			1																4.00	4	4
July 14	1			1																4.00	4	4
July 17	1				1															5.00	5	5
July 19	1		1																	3.00	3	3
Total or average	175	1	20	33	34	35	18	8	4	5	4	1	1	4	2	1	1	2	1	6.34	22	2

PUPÆ OF THE FIRST BROOD

Time of pupation.—The record of the time of pupation of 678 transforming larvæ of the first brood is given in Table 9, and shown graphically in Figure 5. The first pupation is recorded for June 24 and the last for August 4, approximately six weeks apart. The greater amount of pupation took place between July 1 and July 18, inclusive, the maximum pupation being reached on July 5 and July 7.

TABLE 9.—*Time of pupation of 678 transforming larvæ of the first brood of codling moth, Dover, Del., 1919*

Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ
June 24	1	July 5	65	July 14	44	July 23	9
June 25	1	July 6	37	July 15	41	July 24	9
June 26	1	July 7	65	July 16	20	July 25	1
June 27	3	July 8	61	July 17	22	July 26	12
June 28	2	July 9	16	July 18	18	July 29	2
July 1	10	July 10	29	July 19	8	July 30	4
July 2	19	July 11	25	July 20	8	Aug. 4	1
July 3	52	July 12	29	July 21	4		
July 4	32	July 13	20	July 22	7	Total	678

Length of the pupal stage.—As shown in Table 10, the average length of the pupal stage of the first brood was 12.11 days, the maximum 30, and the minimum 5. The average length of the pupal stage of this brood of pupæ is approximately only half as long as the average length of the pupal stage of the spring-brood pupæ.

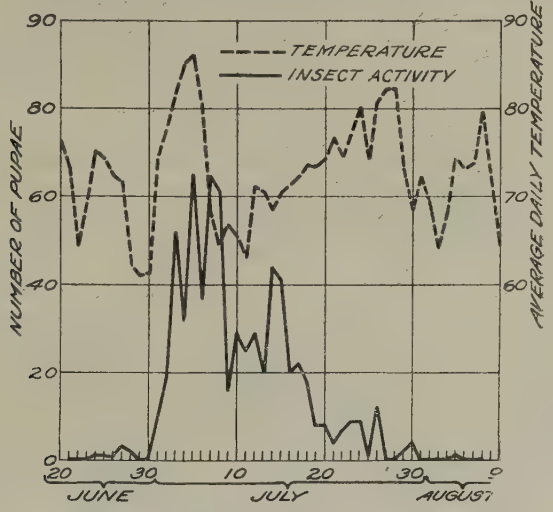

FIG. 5.—Time of pupation of 678 transforming larvæ of the first brood of the codling moth, Dover, Del., 1919

TABLE 10.—*Length of the pupal stage of 522 pupæ of the first brood of codling moth, Dover, Del., 1919*

Date of pupation	Number of individuals	Length of the pupal stage in specified days																		
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	26	30
June 24	1									1										
June 25	1						1													
June 26	1								1											
June 27	3						1				2									
June 28	2								1	1										
July 1	9							2		4		2		1						
July 2	18						3	3	5		5			2						
July 3	43			1		2	1	5	4	11	10	5	2			1			1	
July 4	27							1	10	10	6									
July 5	54				1	1	2	8	8	19	15									
July 6	29						2	3	6	15	1							2		
July 7	57					1	2	4	7	21	13	4	1			2			1	1
July 8	43		1		1	1	2	3	7	16	8		2		2					
July 9	9			1		1		4	1								1		1	
July 10	24			1			1	5	10	3	1			3						
July 11	18					1		1	10	3		1			2					
July 12	22						3	6	10	2	1									
July 13	11				2	1		6	1	1										
July 14	36	1			1	8	7	11	6	1		1								
July 15	30			1		7	4	11	6		1									
July 16	17	1			1	1	5	8		1										
July 17	14		1	1		2	9		1											
July 18	14		1			5	2	5		1										
July 19	7				3		4													
July 20	7							6				1								
July 21	3						1	2												
July 22	2							1		1										
July 23	5				2				2		1									
July 24	7			1				4		2										
July 25	1		1																	
July 26	7					1		3	2				1							
Total	522	2	4	6	11	32	50	102	98	113	64	14	6	6	4	3	1	2	3	1

MOTHS OF THE FIRST BROOD

Time of emergence.—The records of the time of emergence of moths of the first brood were taken from two sources of material: (1) Moths that issued from first-brood larvæ reared in the insectary, and (2) moths that issued from larvæ collected every second or third day from banded apple trees in the orchard. The first of these sources will give the approximate limits of emergence of first-brood moths as accurately as such limits can be determined from reared material, and the second of these sources will give the limits of emergence of first-brood moths under actual field conditions.

From the insectary-bred material as shown in Table 11 and Figure 6, the first moth appeared July 5, and emergence continued daily with a few interruptions until August 11. The maximum emergence was reached on July 19.

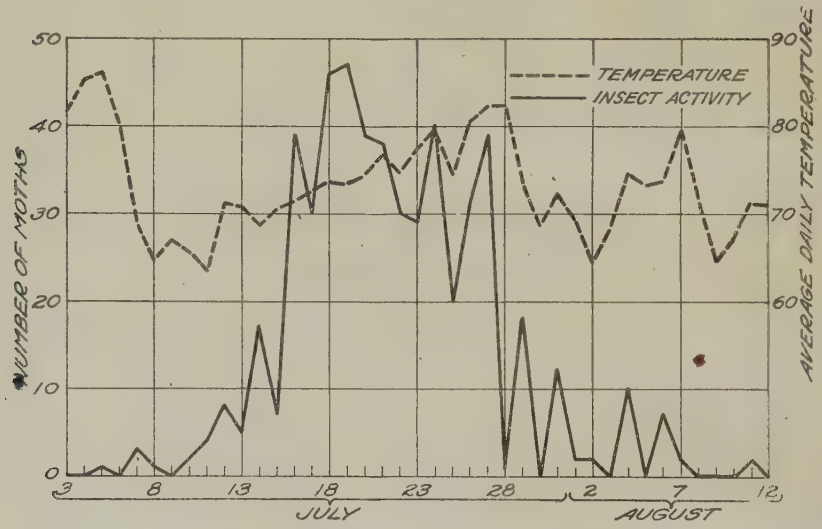

FIG. 6.—Time of emergence of 532 moths of the first brood of the codling moth, insectary-reared material, Dover, Del., 1919

TABLE 11.—*Time of emergence of 532 moths of the first brood of codling moth from material reared at the insectary, Dover, Del., 1919*

Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths
July 5	1	July 15	7	July 23	29	Aug. 1	2
July 7	3	July 16	39	July 24	40	Aug. 2	2
July 8	1	July 17	30	July 25	20	Aug. 4	10
July 10	2	July 18	46	July 26	31	Aug. 6	7
July 11	4	July 19	47	July 27	39	Aug. 7	2
July 12	8	July 20	39	July 28	1	Aug. 11	2
July 13	5	July 21	38	July 29	18		
July 14	17	July 22	30	July 31	12	Total	532

Reference to Table 21 will show that the first moth of the second brood did not emerge until August 22, thus leaving an interval of 10 days from August 11 to August 22 when no moths emerged from the insectary-reared larvæ.

Table 12 and Figure 7 show that such a condition did not occur with the band-collected larvæ. Emergence of moths from this lot of material began July 5 and ended September 6, the maximum emergence occurring on July 24, nearly a week later than that of the insectary-bred material. This is a normal condition in the field and is explained by the fact that there is usually an overlapping of the first and second broods, the end of the one and the beginning of the other probably occurring some time within the period when no moths emerged from the insectary-reared larvæ.

TABLE 12.—*Time of emergence of 1,050 moths of the first brood of codling moth reared from field material, Dover, Del., 1919*

Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths
July 5	8	July 19	30	Aug. 2	14	Aug. 18	8
July 6	8	July 20	28	Aug. 3	4	Aug. 19	9
July 7	10	July 21	36	Aug. 4	10	Aug. 20	1
July 8	12	July 22	52	Aug. 5	11	Aug. 21	5
July 9	15	July 23	102	Aug. 6	7	Aug. 22	1
July 10	10	July 24	146	Aug. 7	10	Aug. 23	5
July 11	20	July 25	95	Aug. 8	10	Aug. 24	5
July 12	9	July 26	56	Aug. 9	6	Aug. 25	2
July 13	21	July 27	7	Aug. 10	5	Aug. 27	4
July 14	29	July 28	66	Aug. 11	3	Aug. 29	2
July 15	4	July 29	20	Aug. 12	3	Sept. 6	1
July 16	16	July 30	9	Aug. 15	12		
July 17	11	July 31	11	Aug. 16	8	Total	1,050
July 18	29	Aug. 1	29	Aug. 17	15		

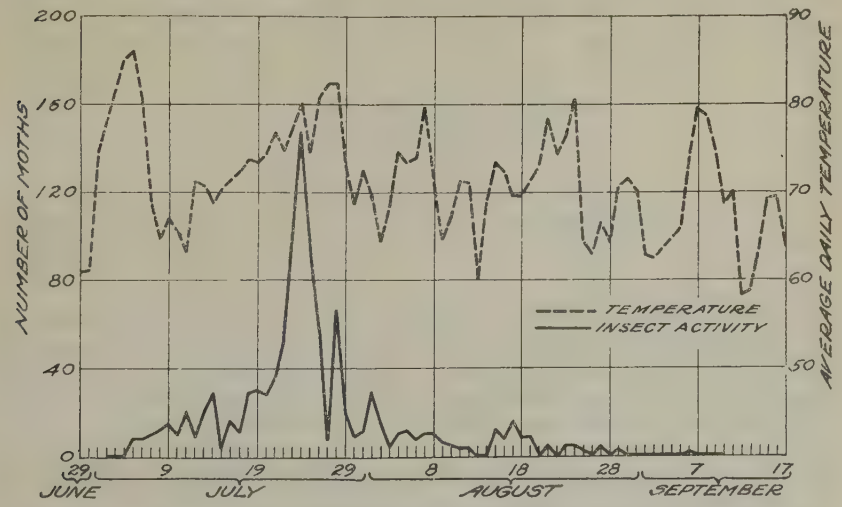

FIG. 7.—Time of emergence of 1,050 moths of the first brood of the codling moth, reared from field material, Dover, Del., 1919

Number of eggs per female moth.—Table 13 shows that 527 moths of the first brood deposited a total of 19,386 eggs, or an average of 36.79 eggs each. The average deposition of eggs of this brood of moths was over three times as great as the moths of the spring brood.

TABLE 13.—*Oviposition by 527 moths of the first brood of codling moth in rearing cages, Dover, Del., 1919*

Cage No.	Number of moths	Sex		Date of—			Total number of eggs deposited	Number of days—		
		Male	Female	Emergence	First oviposition	Last oviposition		Before oviposition	From first to last oviposition	From emergence to last oviposition
1	15	8	7	July 4, 5, 6	July 10	July 12	133			
2	12	3	9	July 7	July 12	July 18	246	5	7	11
3	13	5	8	July 8	July 13	July 21	539	5	9	13
4	16	10	6	July 9	July 12	July 19	490	3	8	10
5	8	5	3	July 10	July 13	July 20	227	3	8	10
6	23	15	8	July 11	do	do	403	2	8	9
7	13	7	6	July 12	July 15	do	211	3	6	8
8	25	12	13	July 13	July 16	do	124	3	5	7
9	46	26	20	July 14	do	July 23	784	2	8	9
10	24	13	11	July 15	July 17	July 20	223	2	4	5
11	37	16	21	July 16	do	July 25	402	1	9	9
12	41	20	21	do	do	July 23	204	1	7	7
13	11	6	5	July 17	do	July 24	81	0	8	7
14	42	21	21	July 18	July 20	July 23	38	2	4	5
15	30	16	14	July 19	July 21	July 24	111	2	4	5
16	28	11	17	July 20	July 22	July 27	637	2	6	7
17	36	17	19	July 21	July 23	Aug. 2	1,196	2	11	12
18	38	11	27	July 22	do	Aug. 1	637	1	10	10
19	36	16	20	July 23	July 24	Aug. 5	1,872	1	13	13
20	32	13	19	do	July 25	July 31	756	2	7	8
21	26	11	15	do	do	Aug. 3	1,497	2	10	11
22	29	14	15	July 24	do	Aug. 6	1,233	1	13	13
23	35	13	22	do	do	July 31	864	1	7	7
24	36	17	19	do	do	do	1,245	1	7	7
25	41	21	20	July 25	July 27	do	343	2	5	6
26	35	20	15	do	do	Aug. 3	329	2	8	9
27	41	21	20	do	do	July 30	526	2	4	5
28	24	11	13	do	do	Aug. 5	519	2	10	11
29	34	14	20	July 26	do	Aug. 6	994	1	11	11
30	34	18	16	do	do	Aug. 4	923	1	9	9
31	8	6	2	July 27						
32	23	14	9	July 28	July 29	Aug. 3	217	1	6	6
33	15	5	10	do	do	Aug. 5	120	1	8	8
34	34	16	18	July 29	July 31	Aug. 6	486	2	7	8
35	9	4	5	July 30	Aug. 4	Aug. 7	77	5	4	8
36	9	3	6	July 31	Aug. 6	do	108	6	2	7
37	11	7	4	do	Aug. 4	Aug. 5	11	4	2	5
38	29	8	21	Aug. 1	Aug. 2	Aug. 8	489	1	7	7
39	10	8	2	Aug. 2	Aug. 4	Aug. 7	91	2	4	5
Total	1,009	482	527				19,386			
Average								2.14	7.19	8.32

Time of oviposition.—The oviposition records of 527 moths of the first brood, confined in 39 cages (Table 13), show that the average number of days which elapsed before oviposition was 2.14, the maximum 5, and the minimum 1; that the average number of days from the first to the last oviposition was 7.19, the maximum 13, and the minimum 2; and that the average number of days from date of emergence to last oviposition was 8.32, the maximum 13 days, and the minimum 5 days.

The first eggs were deposited July 10 by moths which emerged either July 4, 5, or 6, and the last eggs were laid August 8 by moths which emerged August 1.

Length of life of moths.—Table 14 gives a summary of records of the length of life of 1,010 moths of the first brood, 483 being male and 527 female. The average length of life of 483 male moths was 7.17 days, of 527 female moths 7.38 days; the maximum length of life of male moths 14 days, of female moths 15 days; and the minimum length of life of male and female moths 1 day.

TABLE 14.—*Length of life of 483 male and 527 female moths of the first brood of codling moth in captivity, Dover, Del., 1919*

Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths
Days			*Days*			*Days*		
1	5	2	7	75	71	13	15	15
2	13	14	8	69	78	14	1	2
3	24	18	9	48	77	15	0	1
4	36	43	10	53	42			
5	57	61	11	14	19	Total	483	527
6	58	60	12	15	24			

LIFE CYCLE OF THE FIRST GENERATION

Life cycle, stock-jar feeding method.—The length of the life cycle of the first generation of the codling moth, by the stock-jar feeding method, as given in Table 15, includes the time from the deposition of the egg to the emergence of the moth. As the complete life cycle extends from the deposition of the eggs of one generation to the deposition of the eggs of the next, it is necessary to add the average number of days from emergence of moth to first oviposition. In this case 2.14 days (Table 13) should be added to the figures in Table 15 to determine the complete life cycle of female moths. The data in this table cover 526 individuals, and give the incubation period, the average, maximum, and minimum length of the larval feeding period, the pupal period, and the life cycle. The summarized averages by days are: Incubation period, 6.97; larval feeding period, 20.34; cocooning period, 6.40; pupal period, 12.09; life cycle, 45.81, and complete life cycle, 47.95.

TABLE 15.—*Life cycle of 526 individuals of the first generation of codling moth, as observed by rearing, stock-jar feeding method, Dover, Del., 1919*

Date of egg deposition	Number of individuals	Incubation	Larval feeding period			Cocooning period			Pupal period			Life cycle [1]		
			Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
		Days	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
May 26	8	7	21.00	25	18	5.88	11	2	12.75	15	10	46.63	53	40
May 29	6	6	23.00	27	20	5.50	9	3	12.50	15	7	47.00	53	42
May 30	42	6	23.40	32	19	7.29	19	3	12.26	20	7	48.95	66	38
May 31	20	6	26.00	36	20	6.10	16	3	12.40	18	10	50.50	62	44
June 1	5	6	23.80	31	21	5.80	11	4	12.00	13	10	47.60	58	45
June 2	10	6	20.10	33	13	7.40	15	6	12.60	14	10	46.10	56	38
June 3	104	6	22.50	34	17	5.40	13	2	12.49	30	5	46.39	64	39
June 4	74	7	21.68	35	16	5.57	11	2	12.93	26	6	47.17	63	40
June 5	29	7	20.52	28	16	5.76	21	3	12.10	17	6	45.38	56	41
June 6	23	7	19.57	25	15	5.83	15	3	12.39	21	9	44.78	59	37
June 7	27	8	19.93	27	17	7.37	12	3	11.33	19	5	46.63	55	42
June 8	17	8	16.59	22	11	4.82	7	3	13.82	26	10	43.24	55	35
June 9	17	8	16.88	24	12	5.29	9	3	12.65	16	9	42.82	48	36
June 10	40	8	16.55	22	12	7.00	21	3	11.38	14	4	42.93	57	36
June 11	21	8	17.10	20	15	9.00	19	2	10.67	16	7	44.76	55	41
June 12	22	8	15.27	20	13	6.64	11	4	11.82	14	9	41.73	45	38
June 13	27	8	18.41	28	14	8.89	18	4	10.78	13	7	46.08	58	40
June 15	14	7	18.64	24	16	7.50	12	5	10.00	11	8	43.14	50	40
June 16	8	7	16.38	22	14	8.63	14	5	10.88	16	8	42.88	56	38
June 17	12	7	19.00	28	9	6.83	14	3	10.92	12	10	43.75	50	31
Total or average	526	6.97	20.34	36	9	6.40	21	2	12.09	30	4	45.81	66	31

[1] Add 2.14 days for complete life cycle of female moths.

THE SECOND GENERATION

EGGS OF THE SECOND BROOD

Time of deposition.—Table 16 shows the number of eggs deposited daily by moths of the first brood in oviposition jars in the insectary. Reference to either Table 16 or Figure 8 will show that the first eggs were deposited on July 11 and the last on August 6. The date of maximum deposition was July 13, somewhat nearer the beginning of deposition than is ordinarily the case. Although the maximum deposition was reached quickly, it was not followed by any appreciable drop in the number of eggs found daily, but with a few exceptions a rather high average was maintained up to and including the last daily record.

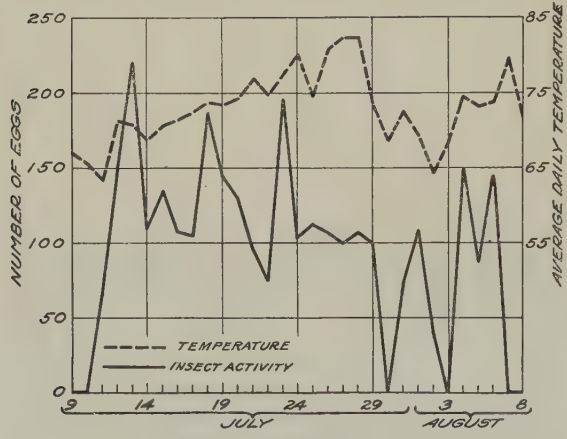

FIG. 8.—Time of deposition of 2,946 eggs of the second brood of codling moth, Dover, Del., 1919

TABLE 16.—*Time of deposition, length of incubation, and time of hatching of 2,946 eggs of the second brood of codling moth, Dover, Del., 1919*

Observation No.	Number of eggs	Date—				Appearance of—		Incubation period
		Deposited	Red ring appeared	Black spot appeared	Hatched	Red ring	Black spot	
						Days	*Days*	*Days*
1	67	July 11	July 14	July 16	July 17	3	5	6
2	148	July 12	July 15	July 17	July 18	3	5	6
3	220	July 13	July 16	July 18	July 20	3	5	7
4	109	July 14	July 17	July 19	July 21	3	5	7
5	134	July 15	July 18	July 20	do	3	5	6
6	107	July 16	July 19	July 21	July 22	3	5	6
7	104	July 17	July 20	July 22	July 23	3	5	6
8	186	July 18	July 21	July 23	July 24	3	5	6
9	145	July 19	do	do	July 25	2	4	6
10	129	July 20	July 22	July 24	do	2	4	5
11	96	July 21	July 23	July 25	July 26	2	4	5
12	75	July 22	July 24	do	July 27	2	3	5
13	194	July 23	July 26	July 27	July 28	3	4	5
14	103	July 24	July 27	July 28	July 29	3	4	5
15	112	July 25	July 28	July 29	July 30	3	4	5
16	107	July 26			July 31			5
17	100	July 27	July 30	July 31	Aug. 1	3	4	5
18	107	July 28	Aug. 1	Aug. 2	Aug. 3	4	5	6
19	100	July 29	Aug. 3	Aug. 4	Aug. 5	5	6	7
20	73	July 31	Aug. 5	Aug. 6	Aug. 7	5	6	7
21	108	Aug. 1	Aug. 6	Aug. 7	Aug. 8	5	6	7
22	40	Aug. 2	do	do	do	4	5	6
23	150	Aug. 4	Aug. 8	Aug. 9	Aug. 10	4	5	6
24	88	Aug. 5	Aug. 9	Aug. 10	Aug. 11	4	5	6
25	144	Aug. 6	Aug. 10	Aug. 11	Aug. 12	4	5	6
Total	2,946	Average				3.23	4.74	5.90

Length of incubation.—A record of the observations of the development and incubation period of eggs of the second brood is given in Table 16. The average number of days from the time of deposition

to the appearance of the red ring was 3.23, the maximum 5, and the minimum 2; the average number of days from the time of deposition to the appearance of the black spot was 4.74, the maximum 6, and the minimum 3; the average length of the incubation period was 5.90 days, the maximum 7, and the minimum 5.

LARVÆ OF THE SECOND BROOD

Time of hatching.—The period of hatching of eggs of the second brood (Table 16 and fig. 9) began on July 17 and continued through August 12, a period of nearly four weeks. The maximum hatch was recorded for July 25, when the period of incubation of 274 eggs was finished.

Length of the feeding period.—In Table 17 the record of the observations of the feeding period of 424 larvæ of the second brood, as determined by the stock-jar feeding method, is given. The first larva entered the fruit July 22 and the last on August 11, two and one-half weeks later. The average length of the feeding period was 24.09 days, the maximum 40, and the minimum 8.[3]

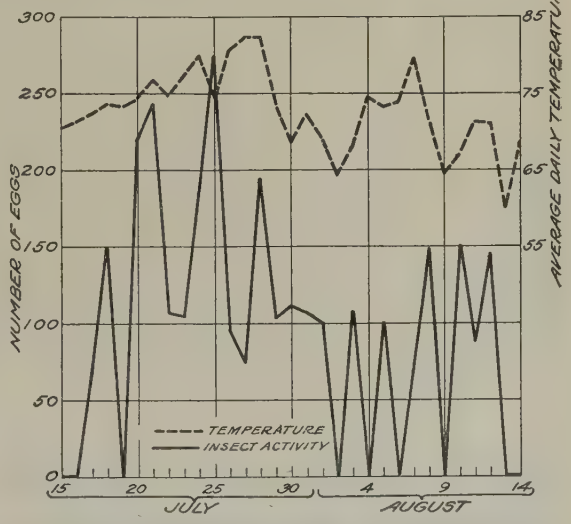

FIG. 9.—Time of hatching of 2,946 eggs of the second brood of the codling moth, Dover, Del., 1919

TABLE 17.—*Length of feeding period of 424 larvæ of the second brood of codling moth, stock-jar method, Dover, Del., 1919*

Date of entering fruit	Number of individuals	Length of feeding period in specified days																														
		8	10	13	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
July 22	4								2					2																	
July 26	8									6			1				1															
July 28	59						1	6	10	1	3	3	2	6	2	5	2	4	4	1	2	1			2	2					2
July 29	65						7	2	9	3		6	3	3	4	6	4	1	3	3	5	3		1	2							
July 30	55					1		5	1	2	4	1	4	1	10	6	2		4	2				5			2	2		3	
July 31	56				1	1	1	1	7	3	4	7		5	7	7		2	2	1	1	1	1					2	1	1	
Aug. 1	46				1	1	4	4	7	2	2	4	5	6				1	1	3	3	1			1						
Aug. 3	55			1	1		1	1		7	7	6	1	7	1	2	2	3	2	5	1	6					1				
Aug. 5	25					1	3	2	3	5	1	1	1		2			3			1				2						
Aug. 6	28		2					1		2	8	1	2	3		1	2	2	4												
Aug. 8	9	1				1	1	2		2				1		1															
Aug. 10	2												2																		
Aug. 11	12								1		3	4	1	1					1		1										
Total	424	1	2	1	4	4	18	24	40	33	32	35	20	35	26	28	13	16	21	15	14	12	1	6	7	2	3	4	1	6

[3] Care was taken to use uninfested fruit, but it is probable that the individuals recorded as having completed their feeding period under 15 days were larvæ which entered the fruit in the field prior to being placed in the cages.

Length of the cocooning period.—The length of the cocooning period of 50 transforming larvæ of the second brood is given in Table 18. The first larva recorded left the fruit August 10 and the last on September 1. The average cocooning period for the 50 individuals was 8.32 days, the maximum 17 days, and the minimum 3 days.

TABLE 18.—*Length of cocooning period of 50 transforming larvæ of the second brood of codling moth, Dover, Del., 1919*

Larvæ left fruit	Number of individuals	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation															Average	Maximum	Minimum
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17			
Aug. 10	1				1												6.00	6	6
Aug. 15	6	1			1	2						1			1		8.67	16	3
Aug. 16	4					1	1				1					1	11.00	17	7
Aug. 17	5		1	1			2					1					7.60	13	4
Aug. 18	3							1	1			1					10.67	13	9
Aug. 20	2					1							1				10.50	14	7
Aug. 21	3					2	1										7.33	8	7
Aug. 22	4		1	1	1	1											5.50	7	4
Aug. 23	4				1	2	1										7.00	8	6
Aug. 24	10					3		2	3	1				1			9.50	15	7
Aug. 25	2							1				1					11.00	13	9
Aug. 26	1			1													5.00	5	5
Aug. 27	2				1	1											6.50	7	6
Aug. 30	2	1			1												4.50	6	3
Sept. 1	1					1											7.00	7	7
Total or average	50	2	2	3	6	14	5	4	4	1	1	4	1	1	1	1	8.32	17	3

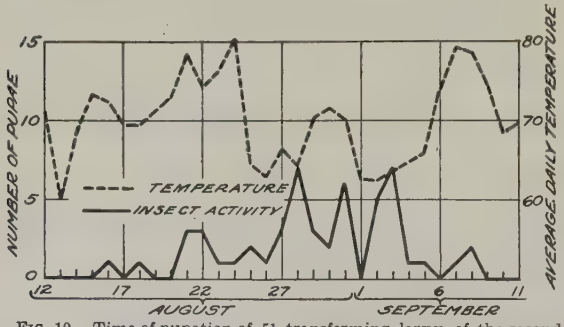

FIG. 10.—Time of pupation of 51 transforming larvæ of the second brood of the codling moth, Dover, Del., 1919

PUPÆ OF THE SECOND BROOD

Time of pupation.—Table 19 and Figure 10 show that pupation of the second brood took place from August 16 to September 8, inclusive. Maximum pupation took place from August 28 to September 3, inclusive, the greatest number pupating on any one day being seven.

TABLE 19.—*Time of pupation of 51 transforming larvæ of the second brood of codling moth, Dover, Del., 1919*

Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ
Aug. 16	1	Aug. 24	1	Aug. 29	3	Sept. 4	1
Aug. 18	1	Aug. 25	2	Aug. 30	2	Sept. 5	1
Aug. 21	3	Aug. 26	1	Aug. 31	6	Sept. 7	1
Aug. 22	3	Aug. 27	3	Sept. 2	5	Sept. 8	2
Aug. 23	1	Aug. 28	7	Sept. 3	7	Total	51

Length of the pupal stage.—The length of the pupal stage of 33 pupæ of the second brood is given in Table 20. The first pupation occurred August 16 and the last September 5. The average length of the pupal period was 12.39 days, the maximum 22, and the minimum 5. The average length of the pupal period agrees very closely with that recorded for the pupæ of the first brood. (Table 10.)

TABLE 20.—*Length of the pupal stage of 33 pupæ of the second brood of the codling moth, Dover, Del., 1919*

Date of pupation	Number of individuals	Length of the pupal stage in specified days													
		5	6	8	9	10	11	12	13	14	15	16	19	20	22
Aug. 16	1							1							
Aug. 18	1												1		
Aug. 21	1									1					
Aug. 22	2				1				1						
Aug. 23	1								1						
Aug. 27	3							2	1						
Aug. 28	6	1	1	1				1		1				1	
Aug. 29	2					1			1						
Aug. 30	2						1		1						
Aug. 31	5				1			2			1	1			
Sept. 2	4							3							1
Sept. 3	3				1		1		1						
Sept. 4	1									1					
Sept. 5	1						1								
Total	33	1	1	1	3	1	3	9	6	3	1	1	1	1	1

MOTHS OF THE SECOND BROOD

Time of emergence.—The time of emergence of moths of the second brood reared from insectary-bred material is presented in Table 21 and Figure 11. The first moth of this brood issued on August 22 and the last on September 24, a period of approximately one month. Maximum emergence occurred August 27 when 12 moths issued.

TABLE 21.—*Time of emergence of 66 moths of the second brood of the codling moth from material reared at the insectary, Dover, Del., 1919*

Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths
Aug. 22	3	Aug. 28	2	Sept. 6	2	Sept. 17	1
Aug. 23	4	Aug. 29	6	Sept. 10	1	Sept. 18	1
Aug. 24	7	Aug. 31	1	Sept. 13	4	Sept. 24	1
Aug. 25	8	Sept. 2	1	Sept. 14	5		
Aug. 26	1	Sept. 4	2	Sept. 15	1	Total	66
Aug. 27	12	Sept. 5	2	Sept. 16	1		

LIFE CYCLE OF THE SECOND GENERATION

Life cycle, stock-jar feeding method.—In Table 22 are given the summarized data showing the average length of each period in the life cycle of the codling moth, as derived from observations of 33 individuals of the second generation reared by the stock-jar method. The average length of the various periods in days is as follows: Incubation, 5.48; larval-feeding, 20.73; cocooning, 8.39; pupal, 12.09; and life cycle, 46.69.

TABLE 22.—*Life cycle of 33 individuals of the second generation of codling moth, as observed by rearing, stock-jar feeding method, Dover, Del., 1919*

Date of egg deposition	Number of individuals	Incubation	Larval feeding period			Cocooning period			Pupal period			Life cycle		
			Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
		Days	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
July 16	1	6	19.00	19	19	6.00	6	6	12.00	12	12	43.00	43	43
July 21	1	5	20.00	20	20	3.00	3	3	19.00	19	19	47.00	47	47
July 23	3	5	19.67	21	19	9.33	12	7	11.67	20	3	45.67	56	34
July 24	10	5	20.80	29	17	9.70	16	5	10.30	14	5	45.80	52	38
July 25	3	5	24.00	25	23	7.33	10	5	11.00	13	9	47.33	49	46
July 26	5	5	23.00	30	18	7.80	13	5	12.80	16	10	48.60	52	44
July 27	1	5	23.00	23	23	9.00	9	9	12.00	12	12	49.00	49	49
July 28	3	6	20.00	21	19	7.00	8	6	11.67	14	9	44.67	46	43
July 29	2	7	18.50	19	18	9.00	11	7	13.50	14	13	48.00	51	45
July 30	3	7	18.33	24	10	9.00	17	3	15.67	22	12	50.00	56	46
Aug. 1	1	7	16.00	16	16	7.00	7	7	12.00	12	12	42.00	42	42
Total or average	33	5.48	20.73	30	10	8.39	17	3	12.09	22	3	46.69	56	34

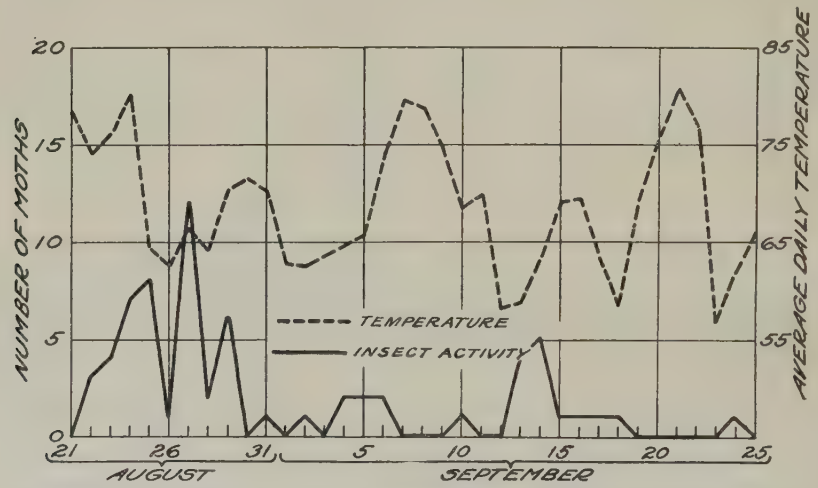

FIG. 11.—Time of emergence of 33 moths of the second brood of the codling moth, Dover, Del., 1919

A comparison of Table 22 with Table 15 shows the average life cycle of the second brood of the codling moth to be slightly less than one day longer than that of the first brood.

THE THIRD GENERATION

EGGS OF THE THIRD BROOD

Time of deposition.—Table 23 shows the number of eggs deposited by moths of the second brood. As shown in Figure 12 and Table 23, the first eggs were deposited August 25, the last September 24, and the maximum, 195, August 31.

Length of incubation.—A record of the observations of the development and incubation period of the eggs of the third brood is found in Table 23. The average number of days from the time of deposition to the appearance of the red ring was 5.03, the maximum 7,

and the minimum 3; the average number of days from the time of deposition to the appearance of the black spot was 6.25, the maximum 7, and the minimum 5; the average length of the incubation period was 7.66, the maximum 11, and the minimum 6.

TABLE 23.—*Time of deposition, length of incubation, and time of hatching of 639 eggs of the third brood of codling moth, Dover, Del., 1919*

Observation No.	Number of eggs	Date—				Appearance of—		Incubation period
		Deposited	Red ring appeared	Black spot appeared	Hatched	Red ring	Black spot	
						Days	*Days*	*Days*
1	11	Aug. 25						
2	34	Aug. 27	Aug. 31	Sept. 3	Sept. 4	4	7	8
3	63	Aug. 28	Sept. 3	Sept. 4	Sept. 5	6	7	8
4	63	Aug. 29	Sept. 4	Sept. 5	Sept. 6	6	7	8
5	20	Aug. 30	do	do	do	5	6	7
6	195	Aug. 31	Sept. 5	Sept. 6	Sept. 7	5	6	7
7	62	Sept. 1	Sept. 7	Sept. 8	Sept. 9	6	7	8
8	10	Sept. 2	Sept. 6	Sept. 7	Sept. 8	4	5	6
9	48	Sept. 3	do	Sept. 8	Sept. 9	3	5	6
10	12	Sept. 4	Sept. 7	do	Sept. 10	3	5	6
11	20	Sept. 6	Sept. 10	Sept. 11	Sept. 12	4	5	6
12	3	Sept. 7						
13	48	Sept. 20			Oct. 1			11
14	43	Sept. 22			do			9
15	7	Sept. 24	Oct. 1			7		
Total	639	Average				5.03	6.25	7.66

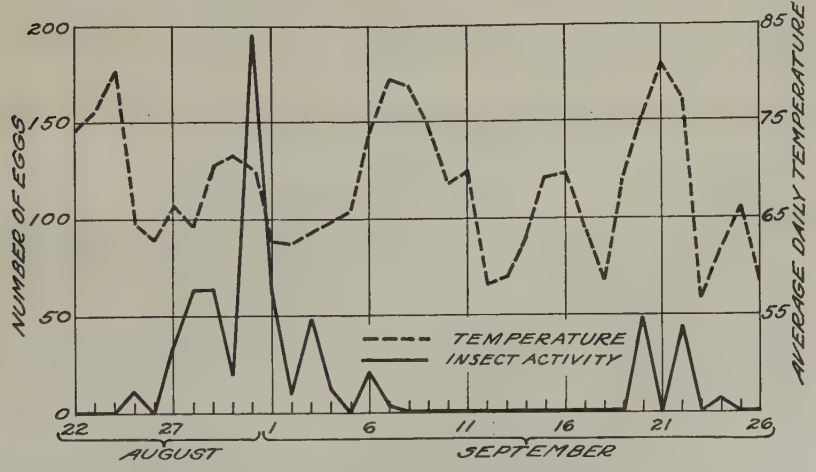

FIG. 12.—Time of deposition of 639 eggs of the third brood of the codling moth, Dover, Del., 1919

LARVÆ OF THE THIRD BROOD

Time of hatching.—The time of hatching of eggs of the third brood (Table 23 and fig. 13) began September 4 and ended October 1, the maximum hatch occurring September 7, just one week from the date of maximum deposition and approximately two weeks after the deposition of the first eggs of the third brood. A number of the eggs failed to develop.

Length of the feeding period.—The length of the feeding period of larvæ of the third brood was established by means of the stock-jar feeding method. The observations of the feeding period of 15 larvæ are recorded in Table 24. Of the 15 larvæ, 7 entered the fruit September 5, and 8 September 9. The average length of the feeding period was 25.07 days, the maximum 32 days, and the minimum 15 days.

TABLE 24.—*Length of feeding period of 15 larvæ of the third brood of codling moth, stock-jar feeding method, Dover, Del., 1919*

Date of entering fruit	Number of individuals	Length of feeding period in specified days				
		15	17	28	29	32
Sept. 5	7			4	3	
Sept. 9	8	2	3			3
Total	15	2	3	4	3	3

The length of the feeding period of 418 larvæ of the second and third broods, reared from moths which transformed from larvæ collected from banded trees, is given in Table 25. Because of the fact that the second and third broods overlap in the field it was not possible to determine positively to which brood the above larvæ actually belonged, and for this reason they are recorded together in one table. The first of these larvæ entered the fruit July 17, the last August 18. The average length of the feeding period was 21.92 days, the maximum 49 days, and the minimum 13 days.

TABLE 25.—*Length of feeding period of 418 larvæ of the second and third broods of the codling moth, band-record material, Dover, Del., 1919*

Date of entering fruit	Number of individuals	Length of feeding period in specified days																												
		13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	37	38	39	40	41	47	49
July 17	17					7	4		1				1						1	2			1							
July 18	6				1			2				1		1		1														
July 20	10			1	1	2		1		1					1		1			2										
July 21	45	1	3	3	9	7	3	5	2	2			1		1			1	1	1				1		2	1		1	
July 22	34		2	2	2	4	2	4	3	3				1	2	3	1	1	1		1		1		1			1		
July 23	36			2	9	1	10	5			2		1		1						2	1	1		1					
July 24	26		3		3	4	3	4		5	1		1								1				1					
July 25	34		3		6	3	1	1	4	3	2	6		2		2											1		
July 26	35			1	1	1		2	5	4	4	1	6	1	2		1		4	1	1									
July 27	33				1	2			5	4	9	2	2	2		1		1	3					1						
July 28	5																4		1											
July 29	21					2	1	1	3		4		1		4	2		2		1										
July 30	30				1	2	3	5	2		1	1	4	1		1	1	3		3		1				1				
July 31	11			2		1	2	2		1		1		1					1											
Aug. 1	22			2				2	2	6	5	2	2					1												
Aug. 3	20			1		2	2	1	1	3		1		2	1		3	1		2										
Aug. 5	1										1																			
Aug. 8	4														1	1				1	1									
Aug. 9	1												1																	
Aug. 11	4												2		1		1													
Aug. 15	11								1	4	4		2																	
Aug. 16	1									1																				
Aug. 18	11						2		1	3	3		1	1																
Total	418	1	11	14	34	38	33	35	30	40	36	15	25	12	14	11	12	10	12	13	5	3	2	2	3	3	1	1	1	1

CODLING-MOTH BAND STUDIES OF 1919

As previously stated, the collecting of codling-moth larvæ from banded trees serves as a basis for comparison of the larvæ living under field conditions with those reared under laboratory conditions. For

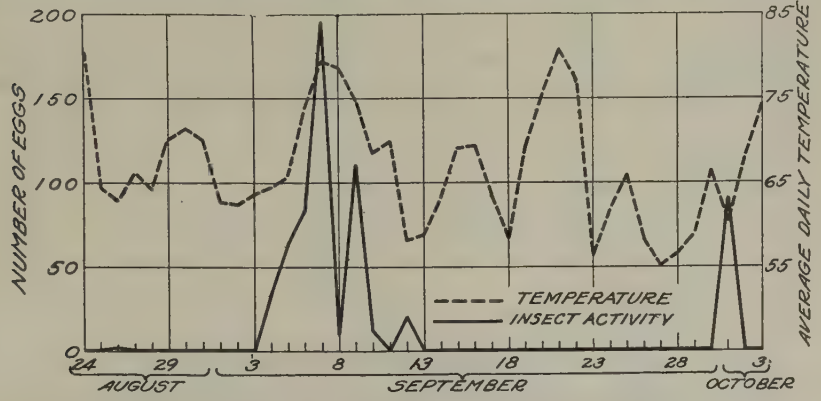

FIG. 13.—Time of hatching of 639 eggs of the third brood of codling moth, Dover, Del., 1919

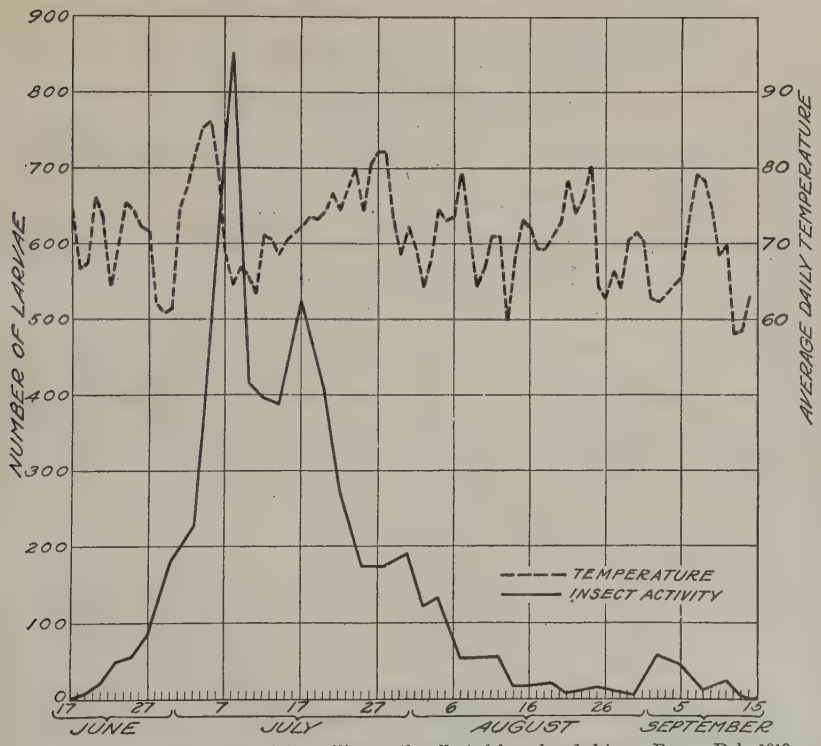

FIG. 14.—Number of larvæ of the codling moth collected from banded trees, Dover, Del., 1919

this reason a number of trees were banded early in the season and the larvæ were collected from beneath these bands every few days. In 1919, as shown in Table 26 and Figure 14, the first larvæ were collected from banded trees June 19 and the last September 13. During

this period 5,559 larvæ were obtained, the maximum number collected at any one time being 851 on July 8. During the season of 1919, 1,050 moths, or 18.89 per cent of the total number of larvæ collected, issued from the band material. The percentage of moths emerging from each collection is shown graphically in Figure 15. No moths emerged in 1919 from the band-collected material after August 12. In the following spring 723 moths, or 13.01 per cent of the total number of larvae collected, issued from the band material. The remainder of the larvæ, 68.1 per cent, failed to reach the adult stage.

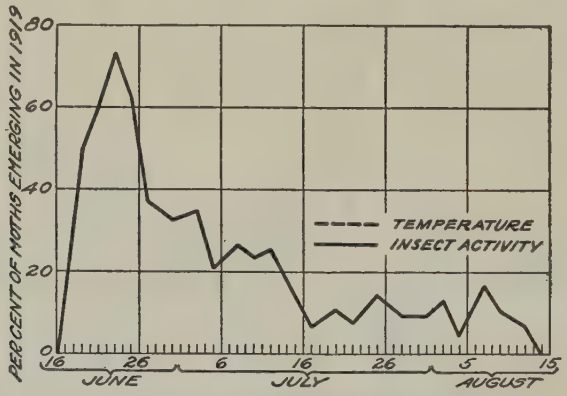

FIG. 15.—Percentage of codling moths emerging on different dates from band-collected material, Dover, Del., 1919

TABLE 26.—*Band-record data of 5,559 larvæ of codling moth collected at Dover, Del., 1919*

Date of collection, 1919	Collection No.	Number of larvæ collected	Total number of moths emerging, 1919	Total number of moths emerging, 1920	Number of moths emerging, 1919	Number of moths emerging, 1920	Number of dead individuals
					Per cent	*Per cent*	*Per cent*
June 19	1	8	4	1	50.00	12.50	37.50
June 21	2	20	12	0	60.00	.00	40.00
June 23	3	49	36	1	73.47	2.04	24.49
June 25	4	56	35	0	62.50	.00	37.50
June 27	5	83	31	6	37.35	7.23	55.42
June 30	6	182	59	7	32.42	3.85	63.73
July 3	7	228	79	12	34.65	5.26	60.09
July 5	8	477	100	18	20.96	3.77	75.27
July 8	9	851	224	60	26.32	7.05	66.63
July 10	10	417	98	44	23.50	10.55	65.95
July 12	11	397	102	50	25.69	12.59	61.72
July 14	12	389	70	54	17.99	13.88	68.13
July 17	13	523	34	51	6.50	9.75	83.75
July 20	14	407	44	76	10.81	18.67	70.52
July 22	15	274	21	42	7.66	15.33	77.01
July 25	16	177	25	24	14.12	13.56	72.32
July 28	17	177	17	15	9.60	8.47	81.93
July 31	18	191	18	49	9.42	25.65	64.93
Aug. 2	19	121	16	36	13.22	29.75	57.03
Aug. 4	20	134	6	48	4.48	35.82	59.70
Aug. 7	21	55	9	18	16.36	32.73	50.91
Aug. 9	22	55	6	22	10.91	40.00	49.09
Aug. 12	23	56	4	26	7.14	46.43	46.43
Aug. 14	24	18	0	6	.00	33.33	66.67
Aug. 16	25	18	0	3	.00	16.67	83.33
Aug. 19	26	21	0	7	.00	33.33	66.67
Aug. 21	27	9	0	4	.00	44.44	55.56
Aug. 25	28	16	0	5	.00	31.25	68.75
Aug. 30	29	6	0	1	.00	16.67	83.33
Sept. 2	30	58	0	17	.00	29.31	70.69
Sept. 5	31	46	0	12	.00	26.09	73.91
Sept. 8	32	13	0	1	.00	7.69	92.31
Sept. 11	33	24	0	4	.00	16.67	83.33
Sept. 13	34	3	0	3	.00	100.00	.00
Total or average		5,559	1,050	723	18.89	13.01	68.10

SEASONAL-HISTORY STUDIES OF 1920

During the season of 1920 the life-history studies of the codling moth were continued and carried out in much the same manner as in the year previous.

PUPÆ OF THE SPRING BROOD

Time of pupation.—The daily observations of the time of pupation of 531 overwintering larvæ are tabulated in Table 27 and illustrated in Figure 16. The first pupation occurred April 12 and the last took place June 22, the maximum being reached May 23. The period of greatest pupation was May 20 to June 3, inclusive, somewhat later than the period of maximum pupation for 1919 as shown by Table 1 and Figure 1. The first pupa of the season, however, was observed April 5, having transformed from a larva collected in the field and brought into the insectary April 3.

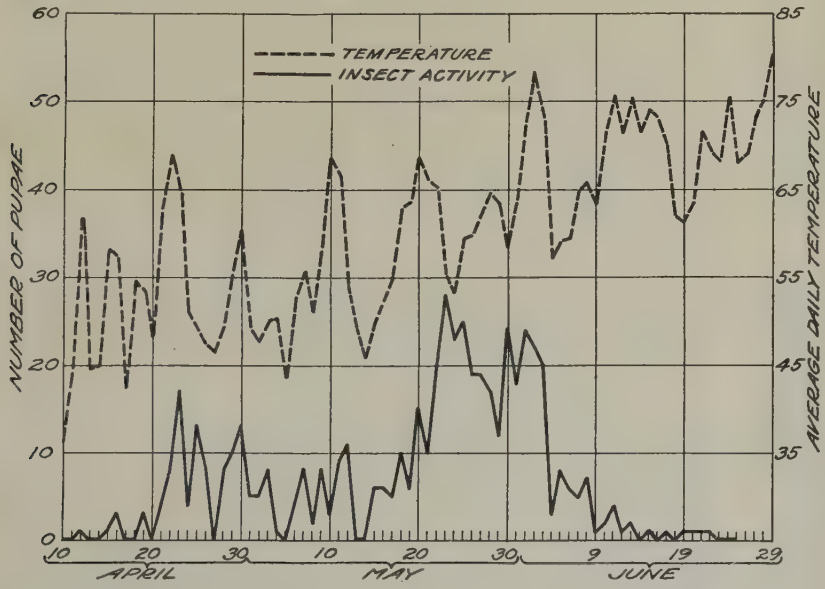

FIG. 16.—Time of pupation of 531 overwintering larvæ of codling moth, Dover, Del., 1919

TABLE 27.—*Time of pupation of 531 overwintering larvæ of codling moth, Dover, Del., 1920*

Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ
Apr. 12	1	May 4	1	May 23	28	June 8	7
Apr. 15	1	May 6	4	May 24	23	June 9	1
Apr. 16	3	May 7	8	May 25	25	June 10	2
Apr. 19	3	May 8	2	May 26	19	June 11	4
Apr. 21	4	May 9	8	May 27	19	June 12	1
Apr. 22	8	May 10	3	May 28	17	June 13	2
Apr. 23	17	May 11	9	May 29	12	June 15	1
Apr. 24	4	May 12	11	May 30	24	June 17	1
Apr. 25	13	May 15	6	May 31	18	June 19	1
Apr. 26	8	May 16	6	June 1	24	June 20	1
Apr. 28	8	May 17	5	June 2	22	June 21	1
Apr. 29	10	May 18	10	June 3	20	June 22	1
Apr. 30	13	May 19	6	June 4	3		
May 1	5	May 20	15	June 5	8	Total	531
May 2	5	May 21	10	June 6	6		
May 3	8	May 22	20	June 7	5		

Length of the pupal stage.—The length of the pupal stage of pupæ of the spring brood was computed from observations made on 416 individuals and recorded in Table 28. The pupal stage steadily decreased in length as the season advanced. The average pupal period was 22.42 days, the maximum 49 days, and the minimum 8 days.

TABLE 28.—*Length of the pupal stage of 416 pupæ of the spring brood of codling moth, Dover, Del., 1920*

Date of pupation	Number of individuals	Length of the pupal stage in specified days																														
		8	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	42	49
Apr. 12	1																												1	
Apr. 15	1																										1			
Apr. 16	2																									1	1			
Apr. 19	2																								1	1				
Apr. 21	3																						1	2						
Apr. 22	8																							5	2	1				
Apr. 23	11																						2	4	5					
Apr. 24	4																								1	2	1			
Apr. 25	7																						2	2	3					
Apr. 26	7																					4	1		2					
Apr. 28	7																				1	2	4							
Apr. 29	9																		1		2	6								
Apr. 30	10																			2	6	1								1
May 1	6																		1	4	1									
May 2	5																		1	4										
May 3	6																	2	3	1										
May 4	1																		1											
May 6	2															1									1					
May 7	7														2	4					1									
May 8	2														2															
May 9	5												3		2															
May 10	1																	1												
May 11	5												3	2																
May 12	8									1		2	2	1	1		1													
May 15	3										2	1																		
May 16	4										2	1					1													
May 17	4									1	1	2																		
May 18	7									1	5	1																		
May 19	4									2	1		1																	
May 20	12									9	3																			
May 21	8									3	4			1																
May 22	17								2	13	2																			
May 23	25		1					1	13	9			1																	
May 24	20	1						3	13	2		1																		
May 25	21						3	10	8																					
May 26	14		1				2	9	1		1																			
May 27	15						14	1																						
May 28	14					2	12																							
May 29	11					7	4																							
May 30	19			1	1	16	1																							
May 31	12				7	4	1																							
June 1	22				18	1	2	1																						
June 2	15			4	5	1	5																							
June 3	17					8	4	4	1																					
June 4	1			1																										
June 5	5					4	1																							
June 6	6				2	3	1																							
June 7	4			1	3																									
June 8	5			2	2	1																								
June 9	1			1																										
June 10	2			1	1																									
June 11	4		1	2	1																									
June 13	1				1																									
June 15	1			1																										
June 20	1				1																									
June 21	1				1																									
Total	416	1	3	14	43	47	50	29	38	41	21	8	10	4	7	4	3	3	7	11	11	13	9	12	17	4	3	1	1	1

MOTHS OF THE SPRING BROOD

Time of emergence.—The time of emergence of 1,620 moths of the spring brood is recorded in Table 29. This table shows that the first emergence took place on May 23, the last on July 9, and the maxi-

mum on June 13. However, empty pupal cases signifying the presence of moths were found in the field on tree trunks prior to the earliest date named above, one empty case being found May 20 and another May 22. Also three moths were found flying about the insectary May 16. The daily rate of emergence is shown in Figure 17

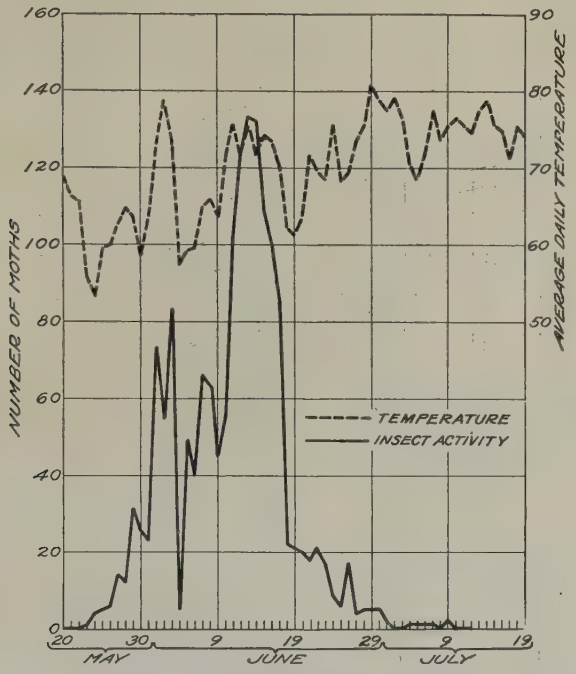

FIG. 17.—Time of emergence of 1,620 moths of the spring brood of the codling moth, Dover, Del., 1920

TABLE 29.—*Time of emergence of 1,620 moths of the spring brood of codling moth, Dover, Del., 1920*

Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths
May 23	1	June 4	5	June 16	100	June 28	5
May 24	4	June 5	49	June 17	85	June 29	5
May 25	5	June 6	40	June 18	22	June 30	5
May 26	6	June 7	66	June 19	21	July 1	2
May 27	14	June 8	63	June 20	20	July 4	1
May 28	12	June 9	45	June 21	18	July 5	1
May 29	31	June 10	56	June 22	21	July 6	1
May 30	26	June 11	102	June 23	17	July 7	1
May 31	23	June 12	124	June 24	9	July 9	2
June 1	73	June 13	133	June 25	5		
June 2	55	June 14	132	June 26	17	Total	1,620
June 3	83	June 15	109	June 27	4		

Oviposition by moths of the spring brood.—The oviposition records of 731 moths of the spring brood, confined in 47 cages with 751 male moths, are given in Table 30. The summarized figures show that the average number of days before oviposition was 3.23, the maximum 7, and the minimum 1; the average number of days of oviposition was 8.42; the maximum 21, and the minimum 2; the average number of days from date of emergence to last oviposition was 10.65, the maximum 23, and the minimum 5.

TABLE 30.—*Oviposition by 731 moths of the spring brood of codling moth in rearing cages, Dover, Del., 1920*

Cage No.	Number of moths	Sex		Date of—			Total number of eggs deposited	Number of days—		
		Male	Female	Emergence	First oviposition	Last oviposition		Before oviposition	From first to last oviposition	From emergence to last oviposition
1	7	5	2	May 26	June 1	June 2	37	6	2	7
2	12	10	2	May 27	---do---	June 8	57	5	8	12
3	25	16	9	May 28	---do---	June 7	75	4	7	10
4	25	11	14	May 29	---do---	June 10	78	3	10	12
5	25	14	11	May 30	June 2	---do---	104	3	9	11
6	45	19	26	May 31	June 3	June 23	219	3	21	23
7	36	19	17	June 1	June 8	June 15	60	7	8	14
8	37	23	14	---do---	June 6	June 13	134	5	8	12
9	34	17	17	June 2	---do---	June 16	197	4	11	14
10	37	17	20	---do---	---do---	June 15	150	4	10	13
11	34	18	16	June 3	---do---	June 14	156	3	9	11
12	40	24	16	---do---	June 8	June 16	228	5	9	13
13	35	16	19	June 5	June 10	June 15	223	5	6	10
14	37	18	19	June 6	June 8	June 14	173	2	7	8
15	37	24	13	June 7	June 10	June 18	165	3	9	11
16	36	23	13	---do---	June 11	June 15	62	4	5	8
17	32	19	13	June 8	June 10	June 23	338	2	14	15
18	33	17	16	---do---	June 11	June 16	199	3	6	8
19	24	12	12	June 9	June 13	---do---	8	4	4	7
20	21	13	8	---do---	June 12	June 15	24	3	4	6
21	31	12	19	June 10	June 14	June 23	136	4	10	13
22	29	18	11	---do---	---do---	June 16	48	4	3	6
23	31	20	11	June 11	---do---	June 24	129	3	11	13
24	30	15	15	---do---	June 13	June 22	235	2	10	11
25	29	20	9	---do---	---do---	June 17	155	2	5	6
26	27	14	13	June 12	---do---	June 24	401	1	12	12
27	32	17	15	---do---	---do---	June 21	531	1	9	9
28	30	15	15	---do---	June 15	June 17	40	3	3	5
29	29	16	13	June 13	June 14	June 21	231	1	8	8
30	33	14	19	---do---	June 16	June 22	133	3	7	9
31	27	9	18	---do---	June 15	June 28	651	2	14	15
32	33	14	19	---do---	June 16	June 21	310	3	6	8
33	35	12	23	June 14	June 17	June 22	129	3	6	8
34	35	18	17	---do---	June 16	June 29	124	2	14	15
35	44	20	24	---do---	---do---	June 27	262	2	12	13
36	31	16	15	June 15	June 17	June 24	224	2	8	9
37	33	17	16	---do---	June 16	June 26	453	1	11	11
38	34	19	15	---do---	June 17	---do---	354	2	10	11
39	33	15	18	June 16	June 18	June 27	71	2	10	11
40	29	10	19	---do---	June 21	June 24	32	5	4	8
41	28	10	18	---do---	June 18	June 27	122	2	10	11
42	46	21	25	June 17	June 21	June 28	292	4	8	11
43	23	13	10	---do---	June 24	June 27	60	7	4	10
44	32	16	16	June 18 / June 19	June 23	July 1	128			
45	30	19	11	June 20 / June 21	June 22	June 26	37			
46	47	16	31	June 22 / June 23	June 26	July 3	43			
47	29	10	19	June 24 / June 25 / June 26	June 28	---do---	13			
Total	1,482	751	731				8,031			
Average								3.23	8.42	10.65

Number of eggs per female moth.—The 731 moths of the spring brood deposited 8,031 eggs, or an average of 10.99 per moth, which is a slightly lower average than that for the corresponding brood of moths in 1919.

Length of life of moths.—As the dead moths were removed from the oviposition cages their length of life was recorded. Table 31 gives the length of life of 1,345 moths—690 males and 655 females. The average length of life of the male moths was 8.33 days, the maximum

24, and the minimum 1 day; while the average length of life of the female moths was 8.75 days, the maximum 24, and the minimum 1.

TABLE 31.—*Length of life of 690 male and 655 female moths of the spring brood of codling moth in captivity, Dover, Del., 1920*

Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths
Days			*Days*			*Days*		
1	5	1	10	73	69	19	2	1
2	12	6	11	52	47	20	1	1
3	28	25	12	33	26	21	1	0
4	53	47	13	23	36	22	1	2
5	71	63	14	23	35	23	3	3
6	81	62	15	15	15	24	4	4
7	77	64	16	4	4			
8	57	74	17	7	7	Total	690	655
9	62	60	18	2	3			

THE FIRST GENERATION

EGGS OF THE FIRST BROOD

Time of egg deposition.—Table 32 and Figure 18 show that the first eggs of the first brood were deposited June 1 and the last July 3, a period of slightly over one month. The height of the deposition period extended from June 8 to June 25, inclusive, the maximum being reached on June 16 when 1,082 eggs were deposited. This date was approximately the middle of the oviposition period. Reference to Table 6 will show that the first eggs were deposited nearly a week earlier in 1919 than in 1920.

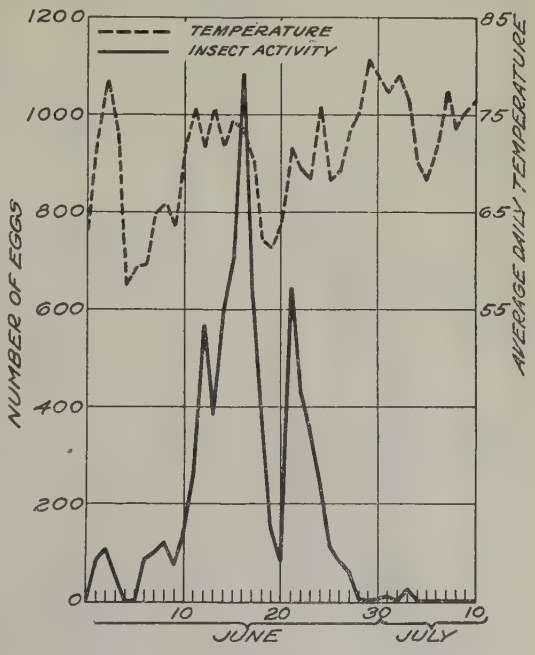

FIG. 18.—Time of deposition of 7,532 eggs of the first brood of the codling moth, Dover, Del., 1919

Length of incubation.—The length of the embryological development and incubation period of eggs of the first brood is given in Table 32. These data may be summarized as follows: The average number of days from date of deposition to appearance of the red ring was 4.42, the maximum 7, and the minimum 3; the average number of days from date of deposition to appearance of the black spot was 6.19, the maximum 8, and the minimum 4; while the average length of incubation period was 7.41 days, the maximum 10, and the minimum 5.

TABLE 32.—*Time of deposition, length of incubation, and time of hatching of 7,582 eggs of the first brood of codling moth, Dover, Del., 1920*

Observation	Number of eggs	Date				Appearance of—		Incubation period
		Deposited	Red ring appeared	Black spot appeared	Hatched	Red ring	Black spot	
						Days	*Days*	*Days*
1	84	June 1	June 4	June 8	June 10	3	7	9
2	105	June 2	June 5	June 9	June 11	3	7	9
3	50	June 3	June 10	June 11	June 13	7	8	10
4	[1] 3	June 4						
5	85	June 6	June 11	June 12	June 14	5	6	8
6	98	June 7	June 12	June 14	June 15	5	7	8
7	119	June 8	do	do	do	4	6	7
8	76	June 9	June 13	June 15	June 16	4	6	7
9	134	June 10	June 15	June 16	June 17	5	6	7
10	265	June 11	June 16	June 17	June 18	5	6	7
11	566	June 12	do	do	do	4	5	6
12	384	June 13	June 17	June 19	June 20	4	6	7
13	601	June 14	June 18	June 20	June 22	4	6	8
14	709	June 15	June 19	June 21	June 23	4	6	8
15	1,082	June 16	June 21	June 23	June 24	5	7	8
16	633	June 17	June 23	June 24	June 25	6	7	8
17	390	June 18	do	June 25	June 26	5	7	8
18	152	June 19	June 24	June 26	June 27	5	7	8
19	82	June 20	do	do	do	4	6	7
20	641	June 21	June 25	June 27	June 28	4	6	7
21	421	June 22	June 26	June 28	June 29	4	6	7
22	354	June 23	June 27	June 29	June 30	4	6	7
23	240	June 24	June 28	do	do	4	5	6
24	111	June 25	do	June 30	July 1	3	5	6
25	82	June 26	June 29	do	do	3	4	5
26	60	June 27	June 30	July 1	July 2	3	4	5
27	5	June 28			July 3			5
28	[1] 2	June 29						
29	[1] 7	June 30						
30	[1] 13	July 1						
31	[1] 4	July 2						
32	[1] 24	July 3						
Total	7,582			Average		4.42	6.19	7.41

[1] Eggs failed to develop.

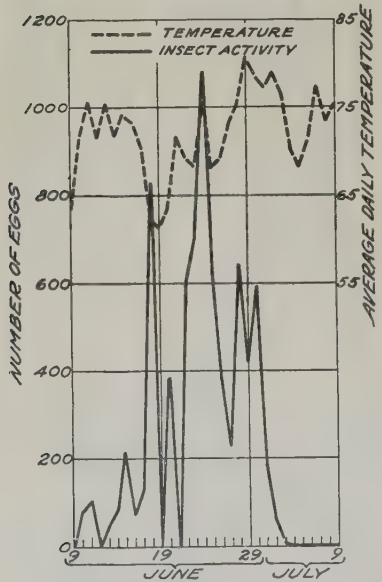

FIG. 19.—Time of hatching of 7,582 eggs of the first brood of the codling moth, Dover, Del., 1920

LARVÆ OF THE FIRST BROOD

Time of hatching.—The time of hatching of eggs of the first brood is given in Table 32 and Figure 19. The first hatching occurred June 10, the last July 3, and the maximum June 24, 8 days after the date of maximum deposition and 14 days after the appearance of the first larva. The eggs deposited after June 28 failed to develop. While the first hatching is recorded in Table 32 as having taken place June 10, a newly hatched codling-moth egg was noted on an apple in an orchard at Woodside on June 7, three days earlier than the first hatching at Dover.

Length of the feeding period, stock-jar feeding method.—The record of the length of the feeding period of 875 larvæ of the first brood by the stock-jar feeding method is given in Table 33. The first larvæ entered the fruit June 10 and the last July 2. The average length of the feeding period was 19.75 days, the maximum 42 days, and the

minimum 10 days. This average is approximately a day and a half shorter than that of the first brood of larvæ in 1919.

TABLE 33.—*Length of the feeding period of 875 larvæ of the first brood of the codling moth, stock-jar feeding method, Dover, Del., 1920*

Date of entering fruit	Number of individuals	Length of feeding period in specified days																																
		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	37	38	39	40	42
June 10	10											1		3	1	2	1							2									
June 11	14											1	1	5				1		3		1	2										
June 13	13									2	3	2	4			1				1													
June 14	16								1		1	2	3	1	2	4		1				1											
June 15	10								2	1	1	1	1		1		1			1									1				
June 16	56							1		5	5	10	3	7	11	7	4	2		1													
June 17	42					1			1	4	4	2	1	1	4	4	7	3	1	1	1	1	1	1			1	1	1			
June 18	35									8	1	2	1	3	2	4	1	4	1		1	4	1						1		1	
June 20	80				1		15	8	3	16	7	7	9	5	1	4		1	1		1	1										
June 22	108					16	17	20	21	6	6	11	3	2	2		1	1				1								1		
June 23	111					7	11	19	18	4	20	11	5	5	3		1	4											1	1	1	
June 24	102					4	11	16	8	11	13	9	7	3	2	2	7	3		2		2		1	1							
June 25	74				4	3	1	14	14	9	5	6	4		1	1	2	4	3					1								
June 26	44					3	3	5	10	3	2	4		2	1		3	5	1				1	1								
June 27	53				3	6	13	2	5	3	4		3	2	1	2	1	1		2			1	1			1			1		1
June 28	34					2	3	3	3	4	5	3		1	1	3	2		1	3												
June 29	34		1	1	2	3	2	6	2	7	2	1			2			2	1		1			1							
June 30	20		2	1		1	3	3	4	1		3	1						1													
July 1	15	1			1		1		4	2			2				1	1					1			1						
July 2	4	1						2																1								
Total	875	2	3	2	11	46	80	99	96	86	79	76	48	40	37	34	32	32	11	14	4	10	8	7	4	2	1	1	3	4	2	1

Length of the cocooning period.—The length of the cocooning period of 408 transforming larvæ of the first brood, which is the time from leaving the fruit until pupation takes place, is given in Table 34.

TABLE 34.—*Length of cocooning period of 408 transforming larvæ of the first brood of the codling moth, Dover, Del., 1920*

Date larvæ left fruit	Number of individuals	Length of cocooning period in specified days, being the time from leaving the fruit to the time of pupation																		Average	Maximum	Minimum
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20	26			
																					Days	*Days*	*Days*
June 30	1				1																5.00	5	5
July 1	4			3	1																4.25	5	4
July 2	10			2	6	1	1														5.10	7	4
July 3	11		1	2	3	2	1		1	1											5.82	10	3
July 4	12			5	4	2	1														4.92	7	4
July 5	21	1	1	12	6	1															4.24	6	2
July 6	41		1	18	14	4	1	2					1								5.00	13	3
July 7	29		4	11	9	4											1				4.93	18	3
July 8	47		3	13	20	5	2			2					1		1				5.47	17	3
July 9	46		7	10	11	10	1	2	1				2		1			1			5.91	20	3
July 10	31		3	12	13	2			1												4.61	9	3
July 11	20	1	2	8	3	2			1			1		1						1	6.45	26	2
July 12	36	1	4	7	3	9	2	2	2	4		2									6.25	13	2
July 13	21		2	4	2	4	1	4	1	2	1										6.43	11	3
July 14	12		1	2	2	1	1	3	1	1											6.42	10	3
July 15	13		1		2	4	2	2					1	1							7.23	14	3
July 16	15				4	1	3		4	1	1			1							7.87	14	5
July 17	6			3	2	1															4.67	6	4
July 18	12		2	4	2	1	2						1								5.42	13	3
July 19	7		1	3	2								1								5.43	13	3
July 20	1										1										11.00	11	11
July 21	1													1							14.00	14	14
July 22	4						1		2	1											8.75	10	7
July 24	1						1														7.00	7	7
July 25	3	1		1		1															4.00	6	2
July 26	2					2															6.00	6	6
July 28	1	1																			2.00	2	2
Total or average	408	5	33	120	110	57	20	15	14	12	3	1	6	5	2	1	1	1	1	1	5.65	26	2

The average length of the cocooning period was 5.65 days, the maximum 26 days, and the minimum 2 days. While the period extended up to 26 days as a maximum, the greater number, 287, or slightly over 70 per cent, cocooned in 4, 5, or 6 days.

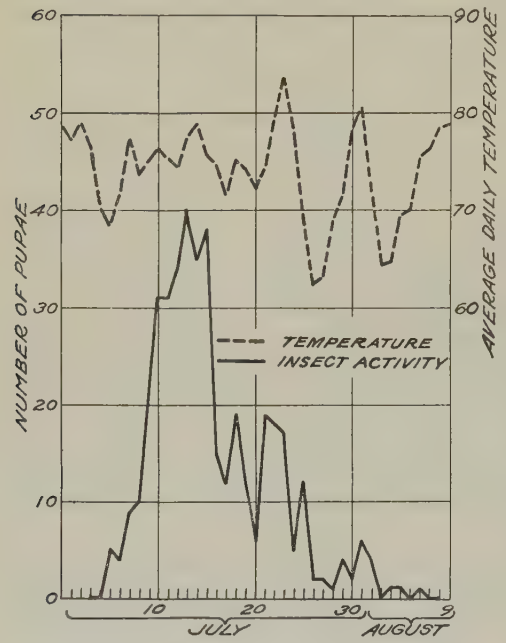

FIG. 20.—Time of pupation of 416 larvæ of the first brood of codling moth, Dover, Del., 1920

PUPÆ OF THE FIRST BROOD

Time of pupation.—The time of pupation of 416 transforming larvæ of the first brood is recorded in Table 35 and shown graphically in Figure 20. The first pupation took place on July 5, the last on August 6, and the maximum July 13, on which date 40 larvæ transformed into pupæ. The period of maximum pupation lasted from July 9 to July 23, inclusive, a period of slightly over two weeks.

Length of the pupal stage.—The records of the length of the pupal period of 326 pupæ of the first brood, beginning with 3 larvæ which pupated July 5 and ending with 1 larva which pupated August 6, are given in Table 36. These records show that the average length of the pupal period was 11.47 days, the maximum 32 days, and the minimum 5 days.

TABLE 35.—*Time of pupation of 416 transforming larvæ of the first brood of the codling moth, Dover, Del., 1920*

Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ	Date of pupation	Number of pupæ
July 5	5	July 14	35	July 23	17	Aug. 1	4
July 6	4	July 15	38	July 24	5	Aug. 2	0
July 7	9	July 16	15	July 25	12	Aug. 3	1
July 8	10	July 17	12	July 26	2	Aug. 4	1
July 9	20	July 18	19	July 27	2	Aug. 5	0
July 10	31	July 19	12	July 28	1	Aug. 6	1
July 11	31	July 20	6	July 29	4		
July 12	34	July 21	19	July 30	2	Total	416
July 13	40	July 22	18	July 31	6		

TABLE 36.—*Length of pupal stage of 326 pupæ of the first brood of the codling moth, Dover, Del., 1920*

Date of pupation	Number of individuals	Length of pupal period in specified days												
		5	6	7	8	9	10	11	12	13	14	15	21	32
July 5	3				1			2						
July 6	4							2	2					
July 7	8						3	5						
July 8	10						1	9						
July 9	23						5	9	9					
July 10	29					1	6	16	5	1				
July 11	26				1	2	6	9	8					
July 12	28			1		1	7	17	2					
July 13	26						2	16	5	3				
July 14	28					2	3	7	6	8		1	1	
July 15	31				1	1	1	5	12	5	5	1		
July 16	12				1				3	6	2			
July 17	6			1					1	3	1			
July 18	13							2	7	3	1			
July 19	8						1	3	1	3				
July 20	6						1	1	1	2				1
July 21	13					1	2	2	5	2	1			
July 22	12			1	1	2		1	2	2	2	1		
July 23	14					1	2	1	1	3	5	1		
July 24	3							2		1				
July 25	7				1	1			1	1	3			
July 26	2			1		1								
July 27	1									1				
July 29	4							2		1		1		
July 30	1						1							
July 31	5	1			2			1	1					
Aug. 1	2				1			1						
Aug. 6	1		1											
Total	326	1	1	4	9	13	41	113	72	45	20	5	1	1

MOTHS OF THE FIRST BROOD

Time of emergence.—Table 37 and Figure 21 give the time of emergence of 348 moths of the first brood reared from insectary-bred material, and Table 38 and Figure 22 give the time of emergence of 1,078 moths of the first brood reared from band-collected material. Emergence from the insectary-bred material began on July 13 and ended on August 21, reaching the maximum on July 23, and emergence from the band-collected material began one day later, July 14, and continued three weeks longer, through September 12, reaching the maximum on July 21, two days earlier than the maximum for

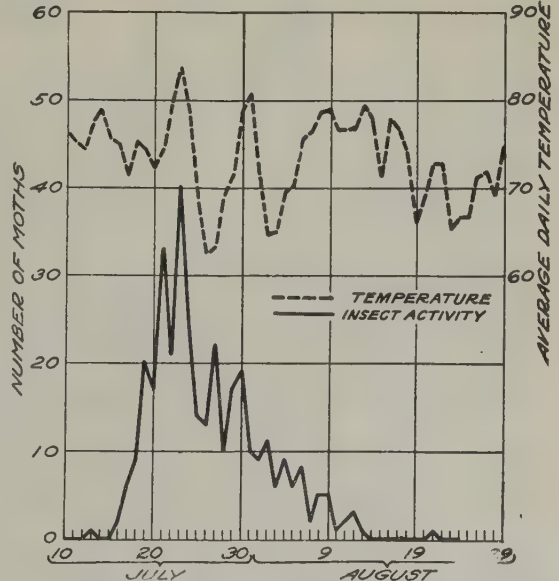

FIG. 21.—Time of emergence of 348 moths of the first brood of the codling moth, insectary-bred material, Dover, Del., 1920

the insectary-bred material. There is a period of 21 days between the last emergence recorded in Table 37 and the last one recorded in Table 38, while reference to Table 47 will show a period of 12 days elapsing between emergence of first and second brood moths from insectary-bred material. This can be explained by the fact that in the field there is an overlapping of the first and second broods which did not take place in the material reared in the insectary. In all probability the dividing line between first and second brood moths as they occur in the field comes in the period of no moth emergence as shown by the insectary-bred material.

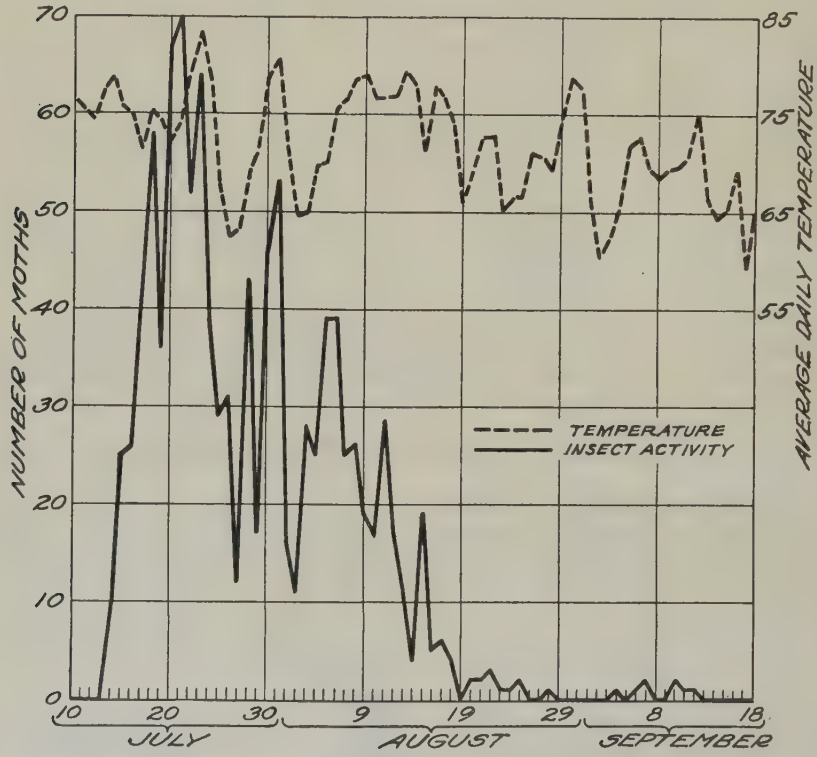

FIG. 22.—Time of emergence of 1,078 moths of the first brood of the codling moth, band-collected material, Dover, Del., 1920

TABLE 37.—*Time of emergence of 348 moths of the first brood of the codling moth from material reared at the insectary, Dover, Del., 1920*

Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths
July 13	1	July 24	25	Aug. 2	11	Aug. 11	2
July 16	2	July 25	14	Aug. 3	6	Aug. 12	3
July 17	6	July 26	13	Aug. 4	9	Aug. 13	1
July 18	9	July 27	22	Aug. 5	6	Aug. 21	1
July 19	20	July 28	10	Aug. 6	8		
July 20	17	July 29	17	Aug. 7	2	Total	348
July 21	33	July 30	19	Aug. 8	5		
July 22	21	July 31	10	Aug. 9	5		
July 23	40	Aug. 1	9	Aug. 10	1		

TABLE 38.—*Time of emergence of 1,078 moths of the first brood of codling moth, band-collected material, Dover, Del., 1920*

Date of emergence	Number of moths emerged	Sex		Date of emergence	Number of moths emerged	Sex	
		Male	Female			Male	Female
July 14	10	4	6	Aug. 9	19	6	13
July 15	25	12	13	Aug. 10	17	7	10
July 16	26	15	11	Aug. 11	28	13	15
July 17	41	20	21	Aug. 12	17	8	9
July 18	58	25	33	Aug. 13	11	8	3
July 19	36	26	10	Aug. 14	4	2	2
July 20	67	33	34	Aug. 15	19	4	15
July 21	70	26	44	Aug. 16	5	2	3
July 22	52	25	27	Aug. 17	6	2	4
July 23	64	23	41	Aug. 18	4	1	3
July 24	39	21	18	Aug. 20	2	1	1
July 25	29	12	17	Aug. 21	2	1	1
July 26	31	11	20	Aug. 22	3	1	2
July 27	12	2	10	Aug. 23	1		1
July 28	43	20	23	Aug. 24	1		1
July 29	17	8	9	Aug. 25	2	1	1
July 30	46	24	22	Aug. 28	1	1	
July 31	53	32	21	Sept. 4	1	1	
Aug. 1	16	10	6	Sept. 6	1		1
Aug. 2	11	6	5	Sept. 7	2		2
Aug. 3	28	14	14	Sept. 10	2	1	1
Aug. 4	25	10	15	Sept. 11	1		1
Aug. 5	39	23	16	Sept. 12	1		1
Aug. 6	39	14	25				
Aug. 7	25	14	11	Total	1,078	498	580
Aug. 8	26	8	18				

Number of eggs per moth.—The number of eggs deposited by 639 moths, confined in 48 cages with 521 male moths, is recorded in Table 39. The moths produced 24,145 eggs, or an average of 37.79 each. This is an increase of one egg per moth over the average for moths of this brood in 1919.

Time of oviposition.—Oviposition by first-brood moths in rearing cages began July 16 and ended August 25. The average number of days from the date of emergence of the moths to the first oviposition was 2.16, the maximum 6, and the minimum 1; the average number of days from the first to the last oviposition was 12.71, the maximum 21, and the minimum 1; the average number of days from date of emergence to last oviposition was 13.87, the maximum 22, and the minimum 2.

Length of life of moths.—A record of the length of life of 1,048 moths of the first brood in captivity, 469 being male and 579 female, is given in Table 40. The average length of life of the male moths was 9.98 days, the maximum 24 days, and the minimum 1 day; while the average length of life of the female moths was 10.62 days, the maximum 23 days, and the minimum 1 day. Reference to Table 14 will show that moths of the corresponding brood in 1919 had an average length of life between two and three days shorter than the moths of this brood in 1920, as shown in Table 40.

TABLE 39.—*Oviposition by 639 moths of the first brood of codling moth in rearing cages, Dover, Del., 1920*

Cage No.	Number of moths	Sex		Date of—			Total number of eggs deposited	Number of days—		
		Male	Female	Emergence	First oviposition	Last oviposition		Before oviposition	From first to last oviposition	From emergence to last oviposition
1	13	7	6	July 13	July 19	July 24	94	6	6	11
2	10	4	6	July 14	July 16	July 29	199	2	14	15
3	25	12	13	July 15	July 17	July 22	335	2	6	7
4	28	16	12	July 16	July 18	July 31	389	2	14	15
5	41	20	21	July 17	do	July 27	533	1	10	10
6	32	14	18	July 18	July 19	Aug. 2	621	1	15	15
7	24	13	11	do	July 20	July 25	144	2	6	7
8	12	8	4	July 19	July 22	July 29	278	3	8	10
9	32	21	11	do	July 21	Aug. 2	159	2	13	14
10	8	6	2	do	do	July 21	5	2	1	2
11	9	2	7	July 20	July 22	Aug. 6	163	2	16	17
12	28	13	15	do	July 21	Aug. 1	517	1	12	12
13	29	14	15	do	do	Aug. 5	337	1	16	16
14	25	11	14	July 21	July 23	Aug. 7	395	2	16	17
15	32	13	19	do	July 22	Aug. 11	142	1	21	21
16	28	11	17	do	July 23	Aug. 5	562	2	14	15
17	15	9	6	July 22	July 24	do	328	2	13	14
18	50	24	26	do	July 23	Aug. 6	1,464	1	15	15
19	33	14	19	July 23	July 26	Aug. 5	634	3	11	13
20	26	10	16	do	July 24	Aug. 13	395	1	21	21
21	29	10	19	do	do	Aug. 9	511	1	17	17
22	37	20	17	July 24	July 25	Aug. 8	413	1	15	15
23	18	4	14	do	July 29	Aug. 5	583	5	8	12
24	14	2	12	July 25	July 27	Aug. 6	288	2	11	12
25	23	12	11	do	July 29	Aug. 16	979	4	19	22
26	11	3	8	July 26	July 28	Aug. 12	94	2	16	17
27	28	9	19	do	July 29	Aug. 7	736	3	10	12
28	18	8	10	July 27	July 30	Aug. 15	655	3	17	19
29	12	2	10	do	July 29	do	161	2	18	19
30	38	16	22	July 28	July 30	Aug. 9	843	2	11	12
31	3	1	2	do	Aug. 2	Aug. 15	44	5	14	18
32	9	3	6	July 29	July 31	Aug. 12	547	2	13	14
33	14	8	6	do	do	Aug. 10	189	2	11	12
34	40	23	17	July 30	Aug. 1	Aug. 13	697	2	13	14
35	47	19	28	July 30–Aug. 3, inclusive	Aug. 2	Aug. 22	1,564			
36	37	18	19	July 31	do	Aug. 12	415	2	11	12
37	26	16	10	Aug. 1–2	Aug. 5	Aug. 21	281			
38	25	11	14	Aug. 3	Aug. 6	Aug. 18	620	3	13	15
39	18	5	13	Aug. 4	do	do	207	2	13	14
40	36	11	25	Aug. 4–12, inclusive	Aug. 9	Aug. 20	1,175			
41	37	21	16	Aug. 5	Aug. 8	Aug. 16	964	3	9	11
42	32	9	23	Aug. 6	do	Aug. 19	1,071	2	12	13
43	21	8	13	Aug. 7	Aug. 9	Aug. 18	189	2	10	11
44	23	6	17	Aug. 8	do	Aug. 24	356	1	16	16
45	16	9	7	Aug. 9	Aug. 11	do	849	2	14	15
46	8	3	5	Aug. 10	Aug. 12	Aug. 21	255	2	10	11
47	24	14	10	Aug. 11	do	Aug. 22	1,272	1	11	11
48	16	8	8	Aug. 12	Aug. 14	Aug. 25	493	2	12	13
Total	1,160	521	639				24,145			
Average								2.16	12.71	13.87

TABLE 40.—*Length of life of 469 male and 579 female moths of the first brood of the codling moth in captivity, Dover, Del., 1920*

Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths	Length of life	Number of male moths	Number of female moths
Days			*Days*			*Days*		
1	8	1	10	34	53	19	3	2
2	12	18	11	40	52	20	3	2
3	13	8	12	32	59	21	4	4
4	25	7	13	31	49	22	1	0
5	25	17	14	26	38	23	1	2
6	22	22	15	26	34	24	1	0
7	35	46	16	22	20			
8	41	48	17	12	21	Total	469	579
9	45	67	18	7	9			

LIFE CYCLE OF THE FIRST GENERATION

Life cycle, stock-jar feeding method.—The life cycle of the first generation of the codling moth, obtained by observation of 329 individuals reared by the stock-jar feeding method, is recorded in Table 41. The average length in days of the incubation period was 7.69; of the larval feeding period, 18.27; of the cocooning period, 5.49; of the pupal period, 11.46; and of the life cycle, 42.91. The average complete life cycle was 45.07 days, obtained by adding to the average life cycle, as shown in Table 41, 2.16 days, which is the average time that elapsed from the emergence of the moths to the deposition of the first egg as shown in Table 39. Reference to Table 15 will show that both the average life cycle and the average complete life cycle of the first generation in 1919 were nearly three days longer.

TABLE 41.—*Life cycle of 329 individuals of the first generation of the codling moth, as observed by rearing, stock-jar feeding method, Dover, Del., 1920*

Date of egg deposition	Number of individuals	Incubation	Larval feeding period			Cocooning period			Pupal period			Life cycle [1]		
			Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
		Days	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
June 1	6	9	22.17	24	20	5.33	7	4	10.83	12	8	47.33	50	42
June 2	8	9	23.38	28	21	4.63	7	3	10.25	12	10	47.26	50	45
June 3	11	10	19.73	21	18	5.91	10	4	11.00	12	10	46.64	51	43
June 6	10	8	22.00	27	17	3.80	5	3	10.90	13	9	44.70	51	40
June 7	8	8	20.38	28	17	4.25	5	3	11.00	13	10	43.63	52	40
June 9	26	7	20.38	24	16	5.58	14	4	11.23	14	8	44.19	58	39
June 10	12	7	22.75	29	18	4.92	7	3	11.92	14	10	46.59	56	40
June 11	14	7	20.71	30	18	5.86	13	3	11.21	14	5	44.79	55	40
June 13	40	7	17.43	22	13	4.70	15	2	11.28	15	7	40.40	50	36
June 14	53	8	15.98	21	14	5.40	20	3	11.21	13	7	40.58	58	36
June 15	38	8	16.63	26	14	5.87	15	2	12.32	32	7	42.81	67	34
June 16	27	8	18.04	25	14	5.81	13	3	11.56	15	8	43.41	54	37
June 17	12	8	17.18	23	13	5.58	10	4	11.50	13	9	42.26	51	36
June 18	13	8	18.46	32	14	6.77	26	2	10.62	14	6	43.85	55	36
June 19	19	8	16.53	28	13	6.42	14	3	11.63	14	9	42.58	54	35
June 21	7	7	19.14	28	14	5.86	11	3	12.43	14	11	44.43	53	37
June 22	13	7	18.46	26	13	6.31	10	2	12.08	15	9	43.84	52	37
June 24	7	6	16.29	18	15	5.14	6	4	11.86	13	10	39.29	41	37
June 25	3	6	18.67	21	17	5.33	9	3	11.33	14	8	41.33	44	38
June 27	2	5	16.00	16	16	4.50	5	4	14.50	15	14	40.00	40	40
Total or average	329	7.69	18.27	32	13	5.49	26	2	11.46	32	5	42.91	67	34

[1] Add 2.16 days for complete life cycle of female moths.

THE SECOND GENERATION

EGGS OF THE SECOND BROOD

Time of deposition.—Table 42 and Figure 23 show that 24,319 eggs of the second brood were deposited between July 16 and August 19, inclusive. The maximum was reached July 30, when 1,342 eggs were deposited.

Length of incubation.—The embryological development and length of incubation of the second-brood eggs are recorded in Table 42. The average number of days from time of deposition to appearance of the red ring was 3.8, the maximum 5, and the minimum 2; the average number of days from the deposition of the eggs to appearance of the black spot was 4.96, the maximum 7, and the minimum 4; while the average length of the incubation period was 5.96 days, the maximum 8 days, and the minimum 5 days.

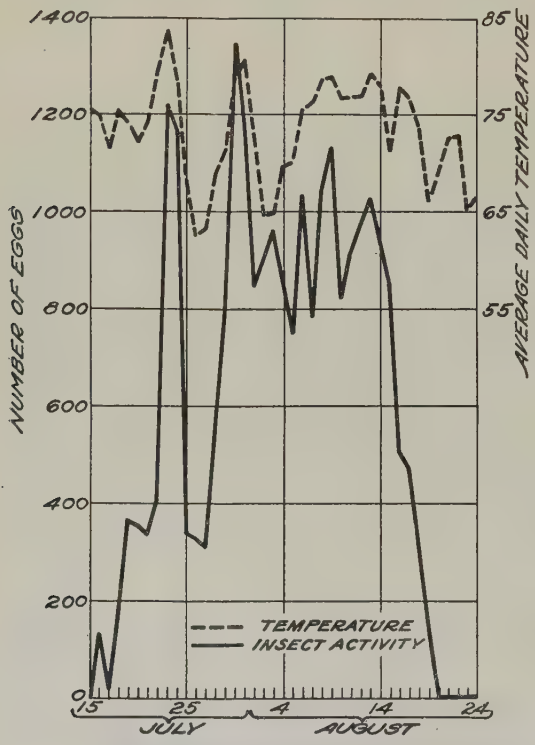

FIG. 23.—Time of deposition of 24,319 eggs of the second brood of the codling moth, Dover, Del., 1920

LARVÆ OF THE SECOND BROOD

Time of hatching.—The hatching of eggs of the second brood took place between July 21 and August 26, as recorded in Table 42 and represented in Figure 24. The maximum hatch took place on August 9, 24 days after the first eggs were deposited, when 1,866 eggs hatched. This date is nearly midway between the time of the first hatch and the last.

Length of the feeding period.—The data on the length of the feeding period of 425 larvæ of the second brood, stock-jar feeding method, are presented in Table 43. The first larvæ entered the fruit July 23, the last August 26, and the maximum number August 9. The average length of the feeding period was 24.94 days, the maximum 45 days and the minimum 16 days.

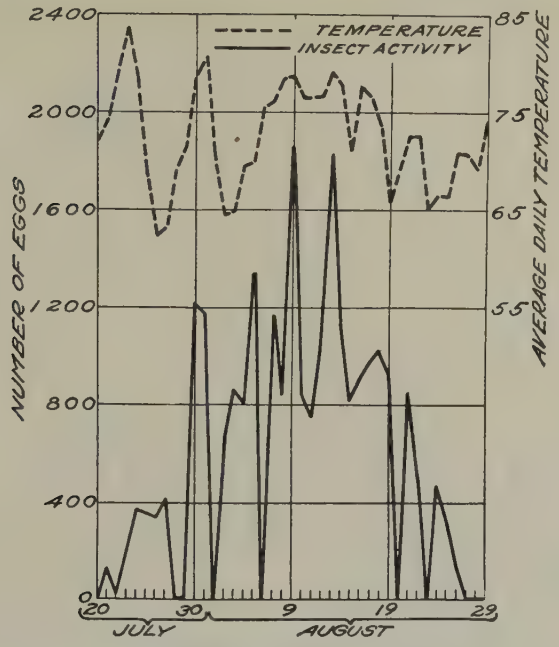

FIG. 24.—Time of hatching of 24,319 eggs of the second brood of codling moth, Dover, Del., 1920

TABLE 42.—*Time of deposition, length of incubation, and time of hatching of 24,319 eggs of the second brood of the codling moth, Dover, Del., 1920*

Observation	Number of eggs	Date				Appearance of—		Incubation period
		Deposited	Red ring appeared	Black spot appeared	Hatched	Red ring	Black spot	
						Days	*Days*	*Days*
1	133	July 16	July 19	July 20	July 21	3	4	5
2	23	July 17	July 20	July 21	July 22	3	4	5
3	178	July 18	July 21	July 22	July 23	3	4	5
4	367	July 19	July 22	July 23	July 24	3	4	5
5	356	July 20	July 23	July 24	July 25	3	4	5
6	339	July 21	July 24	July 25	July 26	3	4	5
7	406	July 22	do	July 26	July 27	2	4	5
8	1,217	July 23	July 28	July 29	July 30	5	6	7
9	1,170	July 24	do	July 30	July 31	4	6	7
10	340	July 25	July 30	Aug. 1	Aug. 2	5	7	8
11	328	July 26	July 31	do	do	5	6	7
12	310	July 27	Aug. 1	Aug. 2	Aug. 3	5	6	7
13	554	July 28	July 31	do	do	3	5	6
14	801	July 29	Aug. 2	Aug. 3	Aug. 4	4	5	6
15	1,342	July 30	do	Aug. 4	Aug. 5	3	5	6
16	1,174	July 31	Aug. 5	Aug. 6	Aug. 7	5	6	7
17	846	Aug. 1	Aug. 6	Aug. 7	Aug. 8	5	6	7
18	904	Aug. 2	Aug. 7	Aug. 8	Aug. 9	5	6	7
19	962	Aug. 3	do	do	do	4	5	6
20	850	Aug. 4	Aug. 8	Aug. 9	Aug. 10	4	5	6
21	756	Aug. 5	Aug. 9	Aug. 10	Aug. 11	4	5	6
22	1,035	Aug. 6	Aug. 10	Aug. 11	Aug. 12	4	5	6
23	787	Aug. 7	Aug. 11	Aug. 12	Aug. 13	4	5	6
24	1,044	Aug. 8	do	do	do	3	4	5
25	1,137	Aug. 9	Aug. 12	Aug. 13	Aug. 14	3	4	5
26	822	Aug. 10	Aug. 13	Aug. 14	Aug. 15	3	4	5
27	913	Aug. 11	Aug. 14	Aug. 15	Aug. 16	3	4	5
28	978	Aug. 12	Aug. 15	Aug. 16	Aug. 17	3	4	5
29	1,028	Aug. 13	Aug. 16	Aug. 17	Aug. 18	3	4	5
30	929	Aug. 14	Aug. 17	Aug. 18	Aug. 19	3	4	5
31	854	Aug. 15	Aug. 19	Aug. 20	Aug. 21	4	5	6
32	505	Aug. 16	Aug. 20	Aug. 21	Aug. 22	4	5	6
33	473	Aug. 17	Aug. 22	Aug. 23	Aug. 24	5	6	7
34	319	Aug. 18	Aug. 23	Aug. 24	Aug. 25	5	6	7
35	139	Aug. 19	Aug. 24	Aug. 25	Aug. 26	5	6	7
Total	24,319	Average				3.80	4.96	5.96

TABLE 43.—*Length of the feeding period of 425 larvæ of the second brood of the codling moth, stock-jar feeding method, Dover, Del., 1920*

Date of entering fruit	Number of individuals	Length of feeding period in specified days																														
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
July 23	4							3	1																						
July 24	3						1		1				1																		
July 25	14					4	1	2	4		1					1					1										
July 26	10			1	3							2		1			1				2										
July 27	4			2	1				1																						
July 28	31					1	6	7	2	1	4	3	1				1				5										
July 29	9					2	1	1		1				1	2			1													
July 30	10		1			1								1		1	1	1	1	1	2										
July 31	4			1			1							1							1										
Aug. 1	7		1	1						1					1	1									2					
Aug. 2	23	1	1		6	3	1	1	2	1	1	1	3					1								1				
Aug. 3	26	1	2	3		4	2		1	2	1		2	2	2	1		1			1		1							
Aug. 4	11		1	2			2	1	3		1									1										
Aug. 5	20	1		1			1	2	2	1	2	2	1	1	2			1	2		1										
Aug. 6	3			1							1						1														
Aug. 7	1		1																												
Aug. 8	28	2	2	3	3	2	1	2	4				5	1	1			2													
Aug. 9	38		1	3	1	4	4	8	5	2				1	3		3		2								1				
Aug. 10	6						2		1			2	1																		
Aug. 11	5							2		1					1			1													
Aug. 12	15				4				1			1	3	1					2		1								1	1
Aug. 13	17			1			1		5	3	1	1			1			1			1	1							1		
Aug. 14	7				2				1		3	1																			
Aug. 15	23					2	3	3	3	2	3	1	2		1		3														
Aug. 16	9				2				1	2	1	1					2														
Aug. 17	22			1					2		7	1	2	1	3	3	1								1						
Aug. 18	6										2	1		1			2														
Aug. 19	12			1		1	1		5				1		1							1		1							
Aug. 20	19						2	3	2		1			1	3	2	3	1		1											
Aug. 22	6					1		1				1	1		2																
Aug. 23	8					1		2	1			1		1		2															
Aug. 24	10				1		2			1	2		3		1																
Aug. 25	7					1			1	2		3																			
Aug. 26	7			1					1		1	1																			
Total	425	5	10	22	23	27	32	38	50	20	32	23	27	14	24	11	18	9	6	5	15	3	1	2	1	2	1	1	1	1	1

Length of the cocooning period.—Table 44 records the length of the cocooning period of six transforming larvæ of the second brood. The first larva left the fruit August 14 and the last August 26. The average length of the cocooning period was 7.17 days, the maximum 12 days, and the minimum 3 days.

TABLE 44.—*Length of cocooning period of six transforming larvæ of the second brood of the codling moth, Dover, Del., 1920*

Date larvæ left fruit	Number of individuals	Length of cocooning period in specified days (time from leaving the fruit to time of pupation)				
		3	6	7	8	12
Aug. 14	1					1
Aug. 17	1	1				
Aug. 18	1				1	
Aug. 19	1		1			
Aug. 22	1			1		
Aug. 26	1			1		
Total	6	1	1	2	1	1

PUPÆ OF THE SECOND BROOD

Time of pupation.—Pupation of the second brood of transforming larvæ began August 20 and ended September 2. Details are given in Table 45 and Figure 25.

TABLE 45.—*Time of pupation of six transforming larvæ of the second brood of the codling moth, Dover, Del., 1920*

Date of pupation	Number of pupæ	Date of pupation	Number of pupæ
Aug. 20	1	Aug. 29	1
Aug. 25	1	Sept. 2	1
Aug. 26	2	Total	6

Length of the pupal stage.—The length of the pupal stage of pupæ of the second brood is recorded in Table 46. Data were obtained on only four individuals, and from these data the average length of the pupal stage was found to be 13.5 days, the maximum 14 days, and the minimum 13 days.

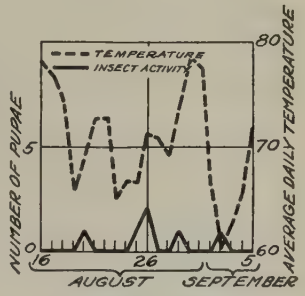

FIG. 25.—Time of pupation of six larvæ of the second brood of codling moth, Dover, Del., 1920

MOTHS OF THE SECOND BROOD

Time of emergence.—The time of emergence of four moths of the second brood from insectary-reared material is recorded in Table 47 and shown graphically in Figure 26. The first moth emerged September 3 and the last September 12. Owing to the small number of moths for which data were obtained, no date of maximum emergence could be determined.

TABLE 46.—*Length of the pupal stage of four pupæ of the second brood of codling moth, Dover, Del., 1920*

Date of pupation	Number of individuals	Length of the pupal period in specified days	
		13	14
Aug. 20	1		1
Aug. 25	1	1	
Aug. 26	1	1	
Aug. 29	1		1
Total	4	2	2

Number of eggs per female moth.—Four moths, two male and two female, were confined in one cage for the purpose of determining the number of eggs per moth of this brood. Table 48 shows that the two females deposited 55 eggs, or an average of 27.5 each.

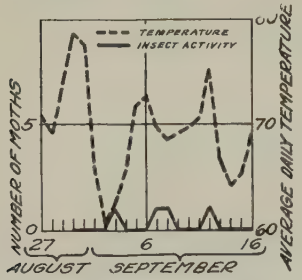

FIG. 26.—Time of emergence of four moths of the second brood of the codling moth, Dover, Del., 1920

TABLE 47.—*Time of emergence of four moths of the second brood of the codling moth from material reared at the insectary, Dover, Del., 1920*

Date of emergence	Number of moths
Sept. 3	1
Sept. 7	1
Sept. 8	1
Sept. 12	1
Total	4

TABLE 48.—*Oviposition by two moths of the second brood of the codling moth in rearing cages, Dover, Del., 1920*

Cage No.	Number of moths	Date of emergence	Sex		Total number of eggs deposited
			Male	Female	
1	4	Sept. 3		1	55
		Sept. 7		1	
		Sept. 8	1		
		Sept. 12	1		
Total	4		2	2	55

LIFE CYCLE OF THE SECOND GENERATION

Life cycle, stock-jar feeding method.—The life cycle of the second generation, as given in Table 49, is in a way not representative of the life cycle of this generation in view of the fact that only four individuals were successfully reared through the complete cycle. The summarized data show the average of the various periods as follows: Incubation 5 days, larval feeding 21.25 days, cocooning 7 days, pupal 13.5 days, and life cycle 46.75 days. Notwithstanding the fact that data were obtained on only four individuals, reference to Table 22 shows that the life cycle as recorded therein coincides very closely with that obtained from the four individuals as given in Table 49.

TABLE 49.—*Life cycle of four individuals of the second generation of the codling moth, as observed by rearing, stock-jar feeding method, Dover, Del., 1920*

Date of egg deposition	Number of individuals	Incubation period	Larval feeding period			Cocooning period			Pupal period			Life cycle		
			Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
		Days	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*	*Days*
July 22	1	5	18.00	18	18	12.00	12	12	13.00	13	13	48.00	48	48
July 23	3	5	22.33	25	20	5.33	7	3	13.67	14	13	46.33	51	42
Total or average	4	5	21.25	25	18	7.00	12	3	13.50	14	13	46.75	51	42

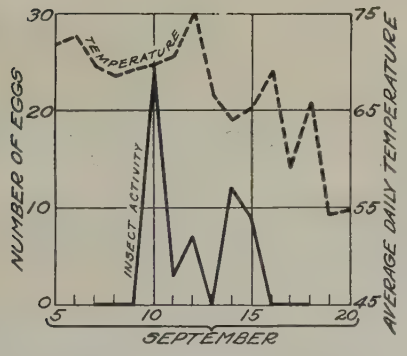

FIG. 27.—Time of deposition of 55 eggs of the third brood of codling moth, Dover, Del., 1920

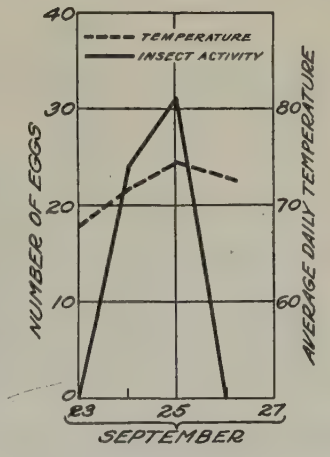

FIG. 28.—Time of hatching of 55 eggs of the third brood of codling moth, Dover, Del., 1920

THE THIRD GENERATION

EGGS OF THE THIRD BROOD

Time of deposition.—Second-brood moths began the deposition of third-brood eggs September 10 and ceased September 15. Further details are given in Table 50 and Figure 27.

Length of incubation.—The embryological changes and incubation period of eggs of the third brood are recorded in Table 50. The data show that the period from the date of deposition to the appearance of the red ring was 4 days; the average period from the date of deposition to the appearance of the black spot was 10.56 days, the maximum 12 days, and the minimum 8 days; the average incubation period was 12.56 days, the maximum 14 days, and the minimum 10 days.

TABLE 50.—*Time of deposition, length of incubation, and time of hatching of 55 eggs of the third brood of codling moth, Dover, Del., 1920*

Observation number	Number of eggs	Date				Appearance of—		Incubation period
		Deposited	Red ring appeared	Black spot appeared	Hatched	Red ring	Black spot	
						Days	*Days*	*Days*
1	24	Sept. 10	Sept. 14	Sept. 22	Sept. 24	4	12	14
2	3	Sept. 11	Sept. 15	Sept. 23	Sept. 25	4	12	14
3	7	Sept. 12	Sept. 16	do	do	4	11	13
4	12	Sept. 14	Sept. 18	do	do	4	9	11
5	9	Sept. 15	Sept. 19	do	do	4	8	10
Total	55	Average				4	10.56	12.56

LARVÆ OF THE THIRD BROOD

Time of hatching.—Eggs of the third brood hatched September 24 and 25, as reference to Table 50 or Figure 28 will show.

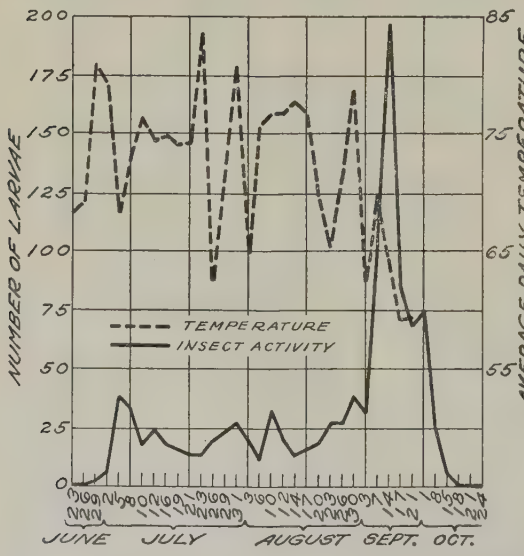

FIG. 29.—Number of larvæ of codling moth collected from banded trees, Pyott orchard, Dover, Del., 1920

No data were obtained on the length of the feeding period of the above larvæ, and the life-history studies at Dover, Del., were brought to a close at this time.

CODLING-MOTH BAND STUDIES OF 1920

As in 1919, larvæ were collected every few days from banded trees in commercial orchards. In 1920 two orchards, the Pyott and Hardesty orchards, were used for this purpose. Data on the collections made in the Pyott orchard are given in Table 51 and Figure 29. These show that 31 collections were made, the first June 29 and the last October 15, from which 1,061 larvæ were obtained. The maximum collection was made on September 14, when 196 larvæ were found. Data on the collections made in the Hardesty orchard are given in Table 52 and Figure 30. Reference to the above will show that 32 collections were made, the first June 23 and the last October 15, from which 3,979 larvæ were obtained. The maximum collection was made on September 14, when 659 larvæ were found. The maximum collection was obtained from both orchards on the same date. No record of the percentage of emergence in 1920 was kept.

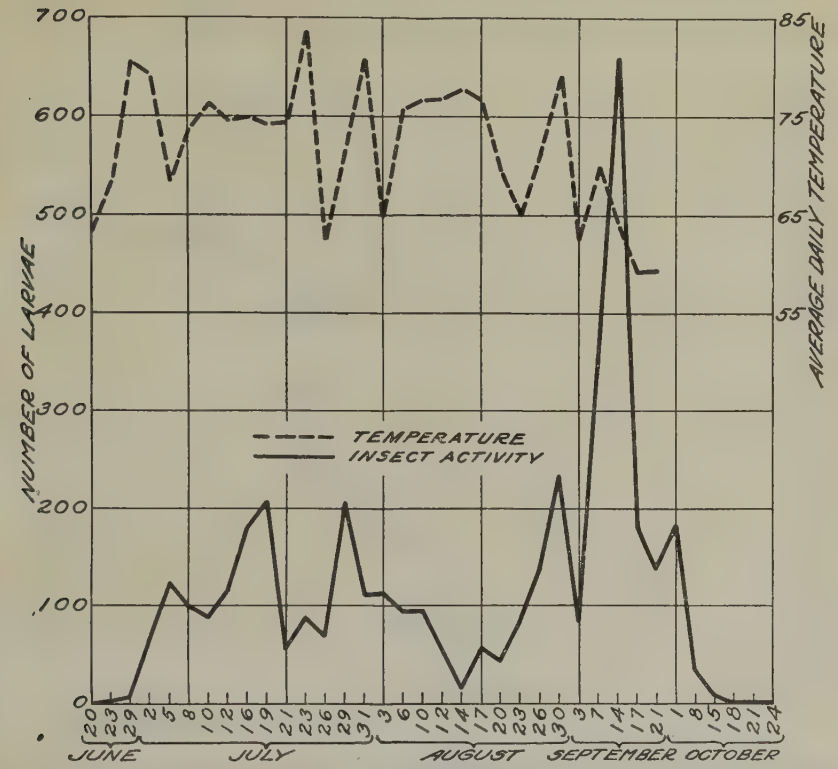

FIG. 30.—Number of larvæ of codling moth collected from banded trees, Hardesty orchard, Dover, Del., 1920

TABLE 51.—*Band-record data of 1,061 larvæ of codling moth collected at the Pyott orchard, Dover, Del., 1920*

Date of collection	Tree No.																											Total
	1	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
June 29					1											1																2
July 2					1											2					2									1		6
July 5	1		4		4											20								1	2					7		39
July 8			2		1		2					1				17											1			9		33
July 10			2													9											1			5	1	18
July 12	3				2			1	1		1					8		1			1	1					1			4		24
July 16			1		3		2			1	1					3					1					1				5		18
July 19	2	1														4		1									2			6		16
July 21			1							2						4		1									1			4		13
July 23					1		1				1					5				1										3	1	13
July 26	2				2			1		1	1					7		1	1								1			2		19
July 29	5	1			1											6		1									2			6	1	23
July 31	2		1				1			1	4		1			6				1		2	1		1		3			2	1	27
Aug. 3	1	2			1		3									9											1			1	2	20
Aug. 6											4					5				1										2		12
Aug. 10		1													1	12					1		2			1	1			9	4	32
Aug. 12	1						2									9				1					1	1				6		21
Aug. 14	2															5		1										3	2			13
Aug. 17	3	1				1										5														2	4	16
Aug. 20		3												2		8		3												1		17
Aug. 23	1	2														12		2											2	1	7	27
Aug. 26	1	3												3		9	3												4	3	1	27
Aug. 30	2	4												2		19		4												3	4	38
Sept. 3	2	2												2		21		2												1	2	32
Sept. 7	2	2													2	59	1	2												30	2	100
Sept. 14		15	7	2	2	3	7	4	4	1	8		2	1		26		12		7	8		10	6	8	13	22		3	20	5	196
Sept. 17	11	3	7						4	1						15	5	8		1	5	2	3				6			12	3	86
Sept. 21	1	2	1		3	2	2	1	4	2	2		1	2		16		4	1		2	1	6		1	1	5			7	2	69
Oct. 1	3		1			1			6	11				2		26		1		3	3			1		1	2		2	11		74
Oct. 8		1		1					1		4					9		1			2						2			3		24
Oct. 15			2		1				1					1												1						6
Total	45	43	29	3	23	7	20	7	21	20	26	1	3	16	3	357	9	45	2	13	26	5	21	11	11	19	52	4	13	166	40	1,061

TABLE 52.—*Band-record data of 3,979 larvæ of codling moth collected at the Hardesty orchard, Dover, Del., 1920*

Date of collection	Tree No.																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
June 23																	1
June 29	1					4											
July 2	6	2	2	7	10	3				3	3		2			1	1
July 5	8	7	2	2	3	1	1				14		5	4	1	8	1
July 8	6	7	2	2		3	1			2	9	1	8	2	1	3	2
July 10	2	8		3	2	2			1	11	1	5	3		1	1	
July 12	6	7	1		3	1			1	1	15	2	11		3	3	2
July 16	10	9		2		1	6	1	3		12	10	12	2	5	4	6
July 19	8	16	4	2	1	8	5	1		4	8	12	13	5	3	7	7
July 21	2	2				3	2			2	4	1	6	2		3	3
July 23	3	8		1	1	6	2	3		1	3	7	4			4	3
July 26	5	10	1			1	1			2	1		8		1	2	1
July 29	16	9	3	2	1	14	13		1		2	7	3	3	10	5	3
July 31	4	2	1				5	1		1	1	14	14	1	6	5	3
Aug. 3	8	9				3	4	1		3	4	5	1		1		
Aug. 6	7	2	4	1	4	10	2			1	3	3	6	3	2	6	2
Aug. 10	12	3		1		4	1		1		2	1	4		1	3	
Aug. 12	8	1	2			1	2				1	2	8	1		2	
Aug. 14	2		1			1							3				
Aug. 17	6	1		1		5	1				4	2	2	1		2	1
Aug. 20	6	1			1	6			2	3	10		3		1		
Aug. 23	7	5	1			15	1		3		11	3	9			3	4
Aug. 26	15	7				20	7	1			16	13	12	3	3	2	1
Aug. 30	17	16				31	17				38	10	23	1	1	1	2
Sept. 3	7	5	1			15	1		3		11	3	9			3	4
Sept. 7	25	30	5		5	42	14	9	5	5	20	16	40	5	1	10	10
Sept. 14	28	26	15		9	125	17	4	7	5	17	32	59	5	7	36	40
Sept. 17	11	7	6		4	29	5		4	3	5	4	15	1	2		7
Sept. 21	8	5				32	4	3	3	1	3	3	8	2	1	15	1
Oct. 1	15	6	6		1	21	12	2	3	3	3	3	9	2	2	9	1
Oct. 8			1		1	1	1	1	2				1			6	2
Oct. 15						1					1			1			1
Total	259	211	58	24	46	409	125	27	39	51	222	159	301	44	53	144	109

Date of collection	Tree No.																		Total
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
June 23																			1
June 29	1																		6
July 2			1	4	13	6							2		1				67
July 5	3		3	3	11			1	7			10	8	7	3	5	2	2	122
July 8	1	1	7	2	5		1		2		1	2	18	8	2				99
July 10	1		5	3	5		2		3		5	8	10	1	2	2		2	89
July 12	3		6	1	9			11	2		3	10	5	1	4	2		1	114
July 16	6	3	2	7	3	6		6	4		8	18	17	8	3	4	2		180
July 19	3	2	4	1	4		2	2	2		9	29	8	9	4	20	1	3	207
July 21	1	1	1					3	2		2	5	5	2	2	1		1	56
July 23		2		1		3		1		1	2	21	1		2	7		1	88
July 26	1	1	1	5	1			2				8	4	2	5	5	1		69
July 29	3			1			3	4	16		5	40	3	12	6	16	1	1	203
July 31	1	1	3	1	3			7	2	1	5	11		3		6	2	6	110
Aug. 3	9	3	1		6		1	6				11		3		18	4	11	112
Aug. 6	1				1				5	2	2	10	3			9	3	3	95
Aug. 10	1	1	2	1	4			3		3	3	12	3			20		8	94
Aug. 12		2			1			1				7	1			9	1	5	55
Aug. 14				3			1					1				2	3	1	18
Aug. 17	1	2	2					1				8				12	1	3	56
Aug. 20										1		8						1	43
Aug. 23										1		10				7	1	2	83
Aug. 26		2	7							1	3	21	1			3	1		139
Aug. 30			6								2	60				1	1	7	234
Sept. 3										1		10			7	1	2	1	84
Sept. 7	1	11	16							1	5	71						3	350
Sept. 14		12	38					2			24	74	29	1		31	7	9	659
Sept. 17			12								2	32	4			23	2	5	183
Sept. 21	1	8	8							1	7	15	1			3	3	3	139
Oct. 1		5	12								2	35				27		3	182
Oct. 8											1	1				11	1	4	34
Oct. 15												2				2			8
Total	38	57	137	33	66	15	10	50	45	13	91	550	123	57	41	247	39	86	3,979

REVIEW OF SEASONAL-HISTORY STUDIES OF THE CODLING MOTH IN 1919 AND 1920

A generalized review of the seasonal-history studies of the codling moth is given graphically in Figures 31 and 32 for the seasons of 1919

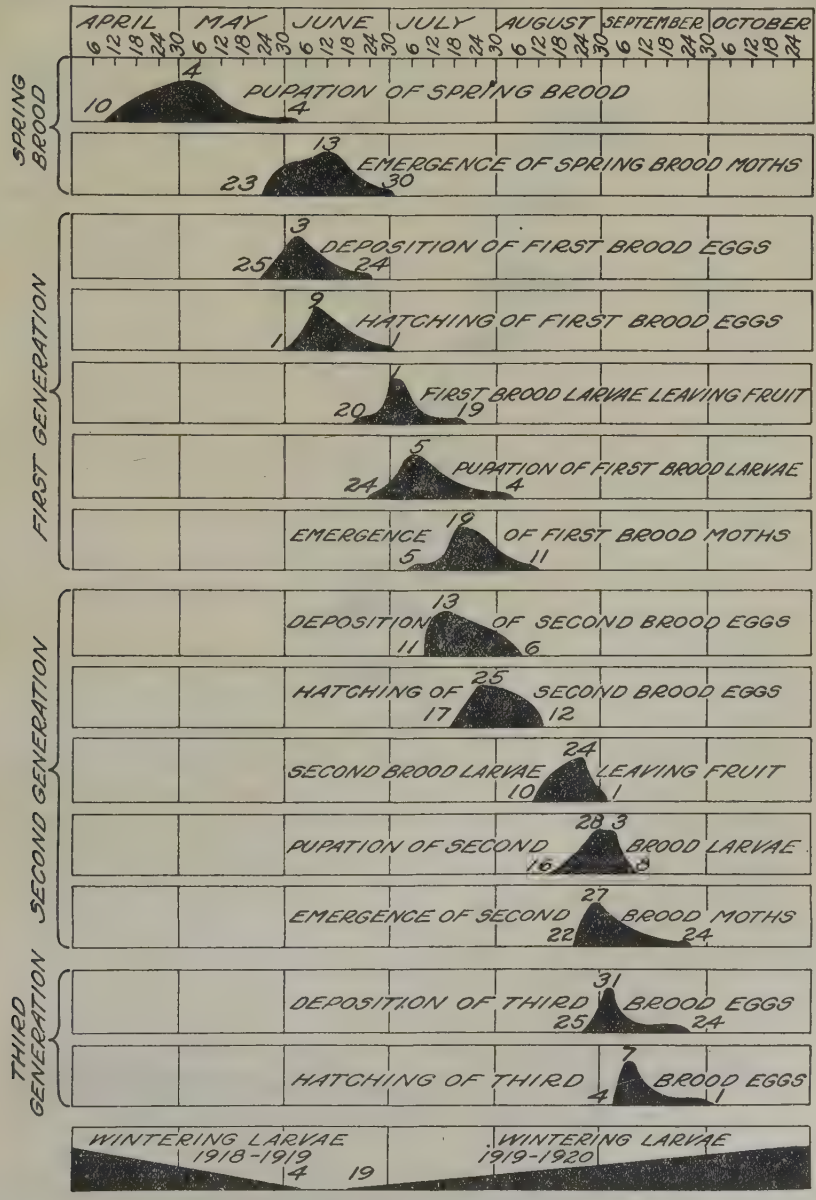

FIG. 31.—Diagram of life history of the codling moth in Dover, Del., 1919

and 1920, respectively. The curves shown in these figures represent approximately the beginning, end, and height of activity of the more important stages of the insect, together with the approximate rate

of development from the beginning of a period to its height and thence to the end. In Figure 32, owing to the small number of individuals under observation, a number of the diagrams are given only in outline, it being considered that representative diagrams could not be made from the small amount of data at hand. A sum-

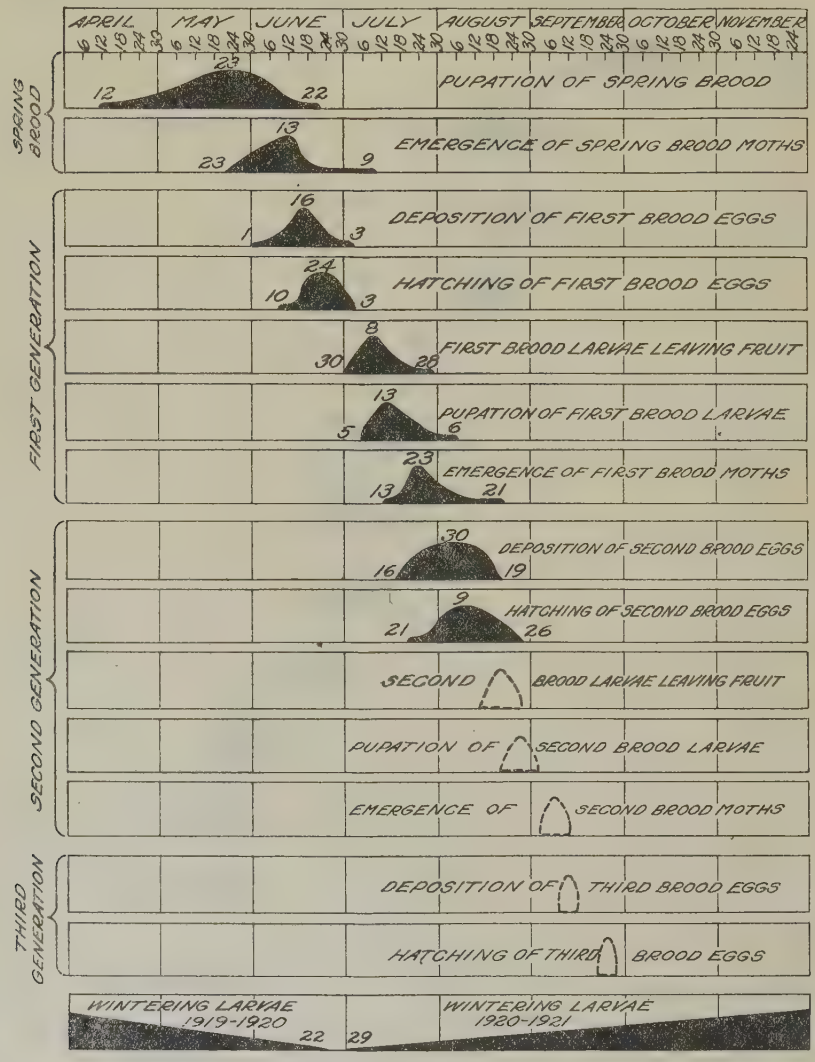

FIG. 32.—Diagram of life history of the codling moth in Dover, Del., 1920

marized account of the beginning, maximum, and end of the more important biological stages for 1919 and 1920 is given in Table 53 for the purpose of a comparison of the seasonal history of these two years. This table shows that the various stages in the seasonal history were somewhat later in 1920 than in 1919, although in both years two broods and a partial third developed.

TABLE 53.—*Summarized comparison of the life history of the codling moth, Dover, Del., 1919 and 1920*

Period	Beginning		Maximum		Ending	
	1919	1920	1919	1920	1919	1920
Spring brood:						
Pupation of larvæ	Apr. 10	Apr. 12	May 4	May 23	June 4	June 22
Emergence of moths	May 23	May 23	June 13	June 13	June 30	July 9
First generation:						
Deposition of eggs	May 25	June 1	June 3	June 16	June 24	July 3
Hatching of eggs	June 1	June 10	June 9	June 24	July 1	---do----
Larvæ leaving fruit	June 20	June 30	July 1	July 8	July 19	July 28
Pupation of larvæ	June 24	July 5	July 5	July 13	Aug. 4	Aug. 6
Emergence of moths	July 5	July 13	July 19	July 23	Aug. 11	Aug. 21
Second generation:						
Deposition of eggs	July 11	July 16	July 13	July 30	Aug. 6	Aug. 19
Hatching of eggs	July 17	July 21	July 25	Aug. 9	Aug. 12	Aug. 26
Larvæ leaving fruit	Aug. 10	----------	Aug. 24	----------	Sept. 1	----------
Pupation of larvæ	Aug. 16	----------	Aug. 28 and Sept. 3	----------	Sept. 8	----------
Emergence of moths	Aug. 22	----------	Aug. 27	----------	Sept. 24	----------
Third generation:						
Deposition of eggs	Aug. 25	----------	Aug. 31	----------	---do----	----------
Hatching of eggs	Sept. 4	----------	Sept. 7	----------	Oct. 1	----------

TABLE 54.—*Summarized comparison of the development of the more important stages of the codling moth, Dover, Del., 1919 and 1920*

Period of development	Average [1]		Maximum [1]		Minimum [1]	
	1919	1920	1919	1920	1919	1920
Spring brood:						
Length of pupal stage	25.13	22.42	39	49	14	8
Length of preoviposition period	2.85	3.23	8	7	1	1
Length of oviposition period	7.69	8.42	17	21	3	2
Period from emergence to last oviposition	9.54	10.65	18	23	5	5
Number of eggs per female moth	12.16	10.99	----------	----------	----------	----------
Length of life of male moths	8.27	8.33	22	24	1	1
Length of life of female moths	8.51	8.75	22	24	1	1
First generation:						
Period from deposition of eggs to appearance of red ring	4.55	4.42	6	7	3	3
Period from deposition of eggs to appearance of black spot	5.55	6.19	7	8	4	4
Length of incubation period	6.64	7.41	8	10	5	5
Length of larval feeding period	21.21	19.75	47	42	9	10
Length of cocooning period	6.34	5.65	22	26	2	2
Length of pupal stage	12.11	11.47	30	32	5	5
Length of preoviposition period	2.14	2.16	5	6	0	1
Length of oviposition period	7.19	12.71	13	21	4	1
Period from emergence to last oviposition	8.32	13.87	13	22	5	2
Number of eggs per female moth	36.79	37.79	----------	----------	----------	----------
Length of life of male moths	7.17	9.98	14	24	1	1
Length of life of female moths	7.38	10.62	15	23	1	1
Second generation:						
Period from deposition of eggs to appearance of red ring	3.23	3.80	5	5	2	2
Period from deposition of eggs to appearance of black spot	4.74	4.96	6	7	3	4
Length of incubation period	5.90	5.96	7	8	5	5
Length of larval feeding period	24.09	24.94	40	45	8	16
Length of cocooning period	8.32	7.17	17	12	3	3
Length of pupal stage	12.39	13.50	22	14	5	13
Third generation:						
Period from deposition of eggs to appearance of red ring	5.03	4.00	7	4	3	4
Period from deposition of eggs to appearance of black spot	6.25	10.56	7	12	5	8
Length of incubation period	7.66	12.56	11	14	6	10
Length of larval feeding period	25.07	----------	32	----------	15	----------

[1] All figures represent days, except those for the number of eggs per moth.

A summarized review of the development of the various stages of the codling moth, together with the average number of eggs per female moth, is given in Table 54 for the years 1919 and 1920, for the purpose of comparing the average, maximum, and minimum length of each stage under observation for the two years named. All figures are in terms of days, except in the case of the item giving the average number of eggs per female moth, which naturally is in terms of eggs.

NATURAL ENEMIES OF THE CODLING MOTH

PREDACIOUS ENEMIES

The predacious enemies of the codling moth in Delaware during the seasons of 1919 and 1920 were too few to have any appreciable effect in reducing the numbers of this pest. One species of beetle, *Tenebroides corticalis* Melsh., was found beneath bands feeding upon the codling-moth larvæ. In addition to this predator, two species of ants were occasionally found feeding on the larvæ beneath the bands.

PARASITIC ENEMIES

Three species of hymenopterous parasites, namely, *Ascogaster carpocapsæ* Vier., *Bassus carpocapsæ* Cush., and *Phanerotoma tibialis* Hald., were frequently present in considerable numbers, especially *A. carpocapsæ*. Three or four other species were present in very small numbers. Table 55 will give some idea of the number of hymenopterous parasites present in 1920. Of 11,482 larvæ collected in the field at various times throughout the season, 3,107 of them, or 27.06 per cent, are recorded as parasitized.

TABLE 55.—*Parasitism of the codling moth by hymenopterous parasites, Dover, Del., 1920*

Number of larvæ collected	When collected	Number of parasites emerged	Percentage of parasitism
1,586	June 14 to June 18	168	10.59
1,821	July 29 to Aug. 26	174	9.56
2,078	Sept. 14 to Oct. 15	132	6.35
5,997	Sept. 25 to Oct. 7	2,633	43.91
11,482		3,107	27.06

DISEASES OF THE CODLING MOTH

A small percentage of hibernating larvæ during the winter of 1919–20 were killed by a fungous disease which was identified by A. T. Speare, of the Bureau of Entomology, as a species of Hirsutella. The early stages of this disease cause the larvæ to become bloated until the entire space within the cocoon is filled up. The larvæ then become inactive until, after death, they appear as a mere chalky mass. In the latter part of the season of 1920 a small proportion of the larvæ were killed by an unidentified wilt disease.

MISCELLANEOUS STUDIES

TIME OF DAY MOTHS EMERGE

Moths of the first brood, 1919.—At the time of emergence of moths of the first brood in 1919, hourly emergence records were kept from 5 a. m. to 7 p. m. in order to determine at what time of day the moths emerge most freely. Records taken of 1,564 moths emerging from July 15 to July 26, inclusive, are given in Table 56. The moths emerged in greatest numbers between 12 m. and 6 p. m., inclusive, although some moths were recorded as emerging at every hour included within the limits of the observations.

TABLE 56.—*Emergence of 1,564 moths of the first brood of codling moth, hourly, from 5 a. m. to 7 p. m., Dover, Del., 1919*

Date of emergence o f moths	Observation number	Number of moths emerging at—															Total number of moths
		A. M.								P. M.							
		5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	
July 15	1	----	----	2	1	5	3	0	1	2	2	5	7	0	----	----	28
July 16	2	13	7	0	12	6	2	1	1	4	12	10	4	9	0	----	81
July 17	3	3	2	3	1	0	4	3	3	4	12	5	10	----	----	----	50
July 18	4	17	0	2	1	1	4	1	4	10	6	9	5	28	----	----	88
July 19	5	4	3	1	4	2	5	7	4	5	12	6	2	21	3	----	79
July 20	6	1	1	1	2	2	4	7	27	8	11	10	5	12	3	----	94
July 21	7	4	2	17	6	6	2	4	13	21	22	14	7	11	11	----	140
July 22	8	4	----	----	10	4	6	20	5	8	37	13	10	3	16	----	136
July 23	9	12	2	3	1	9	13	17	7	54	18	15	23	10	45	----	229
July 24	10	8	0	9	7	5	15	17	48	9	27	20	23	49	9	3	249
July 25	11	3	1	10	27	13	10	10	33	26	22	9	31	5	32	2	234
July 26	12	0	1	2	4	0	9	3	11	34	24	10	20	24	7	7	156
Total	----	69	19	50	76	53	77	90	157	185	205	126	147	172	126	12	1,564

TIME OF DAY MOTHS OVIPOSIT

A series of studies was started in 1919 and continued in 1920 to ascertain the time of day that the moths deposit their eggs most freely.

Moths of the first brood, 1919.—In this experiment six cages were used, in each of which were confined a number of male and female moths. Observations were taken daily every three hours except at 2 a. m.; in other words, observations were made at 5, 8, and 11 a. m., and 2, 5, 8, and 11 p. m. July 29 and the last at 11 p. m. August 5, a period of eight days.

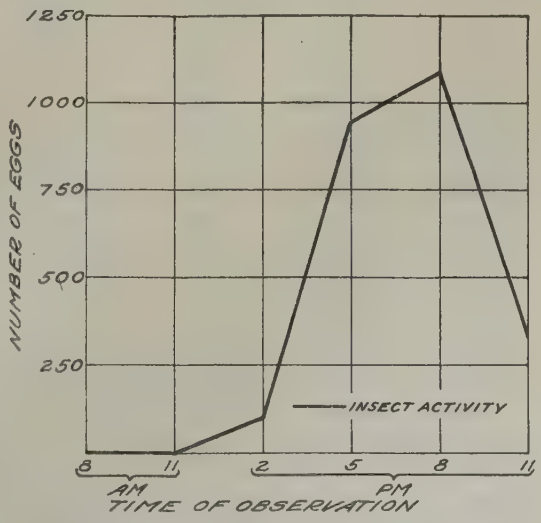

FIG. 33.—Time of day of oviposition of moths of the first brood of the codling moth, Dover, Del., 1919

The first observation was made at 5 a. m.

All eggs found were removed at each examination. Table 57 gives a record of the time of deposition of 2,466 eggs. No eggs were found in the observations made at 5 and at 8 a. m., and 2,031, or approximately five-sixths of the eggs, were found in the observations made at 5 and at 8 p. m., thus indicating that the period of greatest deposition of eggs is between 2 and 8 p. m. The time of oviposition is shown graphically in Figure 33.

TABLE 57.—*Time of oviposition and number of eggs laid by moths of the first brood of the codling moth; observations taken daily every three hours except at 2 a. m.; Dover, Del., 1919*

Date of observation	Cage Number	Number of eggs found deposited at [1]—					Total
		11 a. m.	2 p. m.	5 p. m.	8 p. m.	11 p. m.	
July 29	1	0	0	34	92	0	126
Do	2	0	0	17	8	165	190
Do	3	0	0	4	100	11	115
Do	4	0	0	0	33	0	33
Do	5	0	0	6	29	2	37
Do	6	0	0	0	122	49	171
July 30	1	0	0	0	88	3	91
Do	2	0	24	45	33	7	109
Do	3	0	0	0	18	0	18
Do	4	0	0	0	0	0	0
Do	5	0	0	0	0	0	0
Do	6	0	0	19	101	1	121
July 31	1	0	0	122	47	18	187
Do	2	0	0	10	2	0	12
Do	3	0	2	12	0	0	14
Do	4	0	2	8	7	0	17
Do	5	0	3	9	21	0	33
Do	6	0	0	32	3	0	35
Aug. 1	1	0	7	83	59	7	156
Do	2	0	0	23	8	0	31
Do	3	0	0	6	3	0	9
Do	4	0	0	102	2	0	104
Do	5	0	1	25	15	1	42
Do	6	0	0	0	3	0	3
Aug. 2	1	3	0	7	25	13	48
Do	2	0	0	0	6	0	6
Do	3	0	0	0	1	0	1
Do	4	0	0	0	1	0	1
Do	5	0	0	0	8	0	8
Do	6	0	0	0	0	0	0
Aug. 3	1	0	0	51	16	0	67
Do	2	0	0	14	0	0	14
Do	3	0	0	5	0	0	5
Do	4	0	0	10	0	0	10
Do	5	0	0	12	0	0	12
Do	6	0	0	5	0	0	5
Aug. 4	1	0	4	16	56	18	94
Do	2	0	0	0	0	0	0
Do	3	0	0	0	0	0	0
Do	4	0	1	124	89	30	244
Do	5	0	18	0	0	0	18
Do	6	0	0	30	0	0	30
Aug. 5	1	0	3	12	10	0	25
Do	2	0	0	0	8	0	8
Do	3	0	0	0	0	0	0
Do	4	0	42	65	62	0	169
Do	5	0	0	0	0	0	0
Do	6	0	0	35	12	0	47
Total		3	107	943	1,088	325	2,466

[1] Observations were made at 5 and 8 a. m., but no eggs were found.

Moths of the spring brood, 1920.—Records of the time of oviposition by moths of the spring brood in 1920 were begun at 6 a. m. June 18 and taken thereafter every three hours (except at 3 a. m.) until 12 o'clock midnight, June 24, when the experiment was brought to a

close for this brood of moths. Records were taken from moths confined in six cages. Details of this experiment are given in Table 58 and Figure 34. Of the 937 eggs deposited, 759, or 81 per cent, were recorded in the observations made at 6 and at 9 p. m., and the period of maximum deposition was from 3 to 9 p. m., which agrees with the corresponding experiment carried out in 1919. No eggs were found in the observations made at 6 and at 9 a. m.

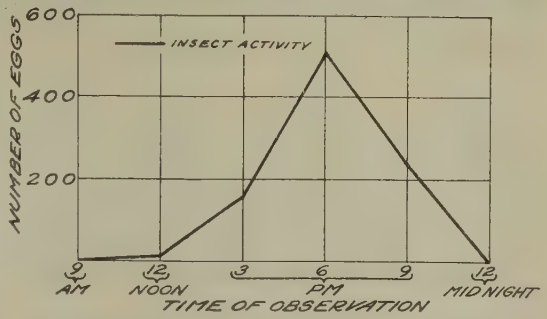

FIG. 34.—Time of day of oviposition of moths of the spring brood of the codling moth, Dover, Del., 1920

TABLE 58.—*Time of oviposition and number of eggs laid by moths of the spring brood of the codling moth; observations taken daily every three hours except at 3 a. m.; Dover, Del., 1920*

Date of observation	Cage Number	Number of eggs found deposited at [1]—					Total
		12 m.	3 p. m.	6 p. m.	9 p. m.	12 p. m.	
June 18	1	0	0	0	0	0	
Do	2	1	0	0	0	1	2
Do	3	0	0	27	0	0	27
Do	4	0	34	30	34	2	100
Do	5	13	20	29	5	0	67
Do	6	0	4	0	2	0	6
June 19	1	0	0	2	7	0	9
Do	2	0	1	15	0	0	16
Do	3	0	1	5	0	0	6
Do	4	0	12	35	11	0	58
Do	5	0	0	0	0	0	0
Do	6	1	0	1	0	0	2
June 20	1	0	0	4	1	0	5
Do	2	0	0	0	0	0	0
Do	3	0	0	1	0	0	1
Do	4	0	0	16	0	0	16
Do	5	0	0	0	0	0	0
Do	6	0	0	0	0	0	0
June 21	1	0	4	15	14	0	33
Do	2	0	68	0	0	0	68
Do	3	0	0	0	1	0	1
Do	4	0	0	78	12	0	90
Do	5	0	0	24	10	0	34
Do	6	0	0	0	0	0	0
June 22	1	0	0	17	0	0	17
Do	2	0	0	0	0	0	0
Do	3	0	3	6	0	0	9
Do	4	0	0	7	2	0	9
Do	5	0	0	0	0	0	0
Do	6	0	0	0	0	0	0
June 23	1	0	0	14	89	0	103
Do	2	0	0	18	0	0	18
Do	3	0	0	38	0	0	38
Do	4	0	0	14	0	0	14
Do	5	0	0	32	6	0	38
Do	6	0	0	5	6	0	11
June 24	1	0	0	28	16	0	44
Do	2	0	0	23	0	0	23
Do	3	0	2	15	14	0	31
Do	4	0	0	4	1	0	5
Do	5	0	11	8	8	0	27
Do	6	0	0	5	4	0	9
Total		15	160	516	243	3	937

[1] Observations were made at 6 and 9 a. m., but no eggs were found.

Moths of the first brood, 1920.—Observations of the time of deposition of eggs by moths of this brood were taken every three hours except at 3 a. m. The first observation was made at 6 a. m., July 23, and the last at 12 midnight, July 29. During this period 1,822 eggs were recorded as deposited in six cages. Table 59 and Figure 35 show the records to agree with previous results, as 1,517 eggs, or slightly over 83 per cent, were found in the observations made at 6 and at 9 p. m. No eggs were found in the observations made at 6 a. m.

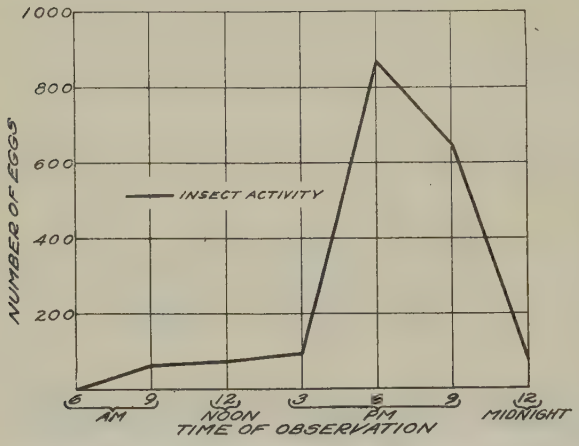

FIG. 35.—Time of day of oviposition of moths of the first brood of the codling moth, Dover, Del. 1920,

TABLE 59.—*Time of oviposition by moths of the first brood of codling moth; observations taken daily every three hours except at 3 a. m.; Dover, Del., 1920*

Date of observation	Cage number	Number of eggs found deposited at [1]—						Total
		9 a. m.	12 m.	3 p. m.	6 p. m.	9 p. m.	12 p. m.	
July 23	1	0	0	0	0	8	4	12
Do	2	0	49	16	40	138	6	249
Do	3	0	2	0	32	42	23	99
Do	4	0	8	0	3	124	0	135
Do	5	0	0	2	0	0	0	2
Do	6	0	0	0	89	124	0	213
July 24	1	0	0	0	45	0	0	45
Do	2	2	3	7	5	0	0	17
Do	3	15	6	0	24	19	12	76
Do	4	4	0	0	25	3	0	32
Do	5	0	0	0	20	2	3	25
Do	6	0	0	2	68	26	0	96
July 25	1	3	0	1	0	0	0	4
Do	2	2	0	0	4	2	2	10
Do	3	7	0	0	2	0	3	12
Do	4	5	2	1	0	2	0	10
Do	5	3	0	5	14	1	0	23
Do	6	0	1	4	23	25	18	71
July 26	1	0	0	0	0	0	0	0
Do	2	0	0	0	14	0	0	14
Do	3	2	0	12	18	3	0	35
Do	4	0	0	0	5	0	0	5
Do	5	2	0	0	2	0	0	4
Do	6	0	0	17	26	16	3	62
July 27	1	0	0	0	0	0	0	0
Do	2	0	0	0	0	0	1	1
Do	3	0	1	0	0	10	0	11
Do	4	0	0	0	0	2	0	2
Do	5	0	1	0	0	0	0	1
Do	6	0	1	0	33	3	1	38
July 28	1	0	0	0	0	0	0	0
Do	2	0	0	0	0	0	0	0
Do	3	1	0	0	0	3	1	5
Do	4	0	0	0	6	2	0	8
Do	5	0	0	0	9	0	0	9
Do	6	2	0	0	53	5	0	60
July 29	1	0	0	7	25	12	0	44
Do	2	4	0	3	143	12	0	162
Do	3	0	0	5	12	40	0	57
Do	4	10	0	10	102	23	0	145
Do	5	0	0	0	25	0	0	25
Do	6	0	0	0	0	3	0	3
Total		62	74	92	867	650	77	1,822

[1] Observations were made at 6 a. m., but no eggs were found.

OVIPOSITION BY INDIVIDUAL MOTHS

Studies of the number of eggs deposited by individual moths were made in 1919 and 1920 by isolating pairs of male and female moths in separate cages. The cages were examined daily and a record made of all eggs found.

Moths of the spring brood, 1919.—Table 60 gives the number of eggs deposited by each female and the day on which they were deposited. In this experiment no records of those which failed to oviposit are included. In all, 12 paired females deposited 207 eggs from May 23 to June 17, inclusive, giving an average of 17.25 eggs per cage. The maximum number of eggs deposited by any individual was 79, and the minimum (for those which oviposited) was 2.

TABLE 60.—*Oviposition by individual moths of the spring brood of codling moth, Dover, Del., 1919*

Pair No	Date of oviposition													Total
	May							June						
	23	24	25	26	27	28	31	2	9	10	11	12	17	
1	2	2												4
2	11	1												12
3			21	31	22	5								79
4			1	1		1	1							4
5							3							3
6								5						5
7								5						5
8									1			12		13
9									2					2
10										42				42
11											26	8		34
12												2	2	4
Total	13	3	22	32	22	6	4	10	3	42	26	22	2	207

Moths of the first brood, 1919.—Records of the oviposition of the females of 233 pairs of moths of the first brood are given in Table 61. Of these 233 pairs, only 59, or slightly over 25 per cent, deposited any eggs. Sixteen out of the fifty-nine pairs which did oviposit, or slightly over 27 per cent, deposited only a single egg. Those which failed to oviposit are not listed in the table. Oviposition began July 22 and ceased August 26. No eggs were deposited between August 7 and 13 and between August 18 and 26. During this period 1,277 eggs were laid. Considering only those which oviposited, this gives an average of 21.64 eggs per female, with a maximum of 106 and a minimum of 1; whereas, considering the total 233 pairs under observation, the average was 5.48 eggs per female, with a maximum of 106 and a minimum of 1.

TABLE 61.—*Oviposition by 59 individual moths of the first brood the of codling moth, Dover, Del., 1919*

Pair No.	Date of oviposition																					Total
	July									August												
	22	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	13	15	16	18	26	
1	15																					15
2	1																					1
3	1																					1
4		1																				1
5		4																				4
6		29	7																			36
7		3	6																			9
8				1																		1
9				85		8		7														100
10			1																			1
11						3																3
12									1													1
13								1														1
14											1											1
15			5																			5
16						5	3															8
17				50		2			1													53
18								1														1
19				6		1																7
20				1		4																5
21				16																		16
22				9																		9
23				3																		3
24				5		1																6
25				8	2																	10
26				1	8	50	47															106
27						10	11															21
28					1																	1
29									4	1												5
30							3	26														29
31								1														1
32							10	32														42
33							43															43
34											11											11
35								39	13		31											83
36									1													1
37								43	27	14												84
38													1									1
39								1			1											2
40								44	7	29												80
41								69														69
42								17		4												21
43								1														1
44														2		6						8
45													2									2
46										14	2				7							23
47											6											6
48											1											1
49											20	3	1	17								41
50											57	6										63
51												63	1									64
52												5	34		3							42
53															1							1
54												4			2	2						8
55														36								36
56																			14			14
57																	11					11
58																		4	34	6		44
59																					14	14
Total	17	37	19	185	11	84	117	282	54	62	130	81	39	55	13	8	11	4	48	6	14	1,277

Moths of the spring brood, 1920.—Data as to the number of eggs deposited by individual pairs of moths were obtained in the same manner as in 1919. Out of 75 paired females observed only 22 deposited eggs. As shown in Table 62, the 22 female moths deposited 455 eggs from June 9 to June 27, inclusive. Considering only the individuals which oviposited, this gives an average of 20.68 eggs,

with a maximum of 99 and a minimum of 1; while for the total number of pairs under observation the average was 6.07 eggs, with a maximum of 99, and a minimum of 1.

TABLE 62.—*Oviposition by 22 individual moths of the spring brood of the codling moth, Dover, Del., 1920*

Pair No.	Date of deposition, June																			Total
	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
1	3																			3
2				8	4	2														14
3						4														4
4								1	2	2	5									10
5							2			4	8									14
6		2		41	11	10	6													70
7				9	2		2													13
8		2		2	7	9														20
9			1	16		2	6													25
10									42	16	5									63
11									10											10
12									23	7	1	2								33
13									5											5
14											2	5	4		6				1	18
15										1										1
16												2								2
17													6							6
18													2	2						4
19																1				1
20											38									38
21													1		1					2
22											3		52	8		19	4	9	4	99
Total	3	4	1	76	24	27	16	1	82	30	62	9	65	10	7	20	4	9	5	455

Moths of the first brood, 1920.—Pairs of moths of the first brood of 1920 were observed for the number of eggs deposited and the date of each deposition. Of the 181 paired females observed, 76 deposited 1,859 eggs from July 26 to August 24, inclusive, while 105 pairs failed to deposit any eggs and are consequently omitted from Table 63, in which the details are recorded. Eight females deposited only one egg each. The average number of eggs deposited by the females ovipositing was 24.46, the maximum 209, and the minimum 1; while the average number of eggs for the total number of females under observation was 10.27, the maximum 209, and the minimum 1.

TABLE 63.—*Oviposition by 76 individual moths of the first brood of codling moth, Dover, Del., 1920*

Pair No.	Date of oviposition																											Total
	July					August																						
	26	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
1		1																												1
2					1																									1
3		2			6																									8
4				42																										42
5				11				1																						12
6	4		2			4																								10
7				1	39		3																							43
8							3																							3
9												2																		2
10														2	2															4
11													1																	1
12								20	15	2	17																			54
13																8														8
14														3																4
15																14														13

TABLE 63.—*Oviposition by 76 individual moths of the first brood of codling moth, Dover, Del., 1920*—Continued

Pair No.	Date of oviposition																											Total
	July					August																						
	26	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
16															6														6
17													9	16		16													41
18													10																10
19															1			1	2										4
20																		3	8	7			3	13					34
21												5	6	2	17	67													97
22												78	43	29	33	26													209
23															5		1	1		11		1							19
24															22														22
25																3	9												12
26														19	10					8									37
27														9	6		3	2											20
28														2															2
29													8	4	5	12	1	1	5		3	3							42
30																1													1
31																			4	6									10
32																				6									6
33																				9									9
34																1		10	27	16	27	4							85
35															3														3
36																82													82
37																				3	1								4
38																			2										2
39																		3											3
40																3													3
41																	38	14	53										105
42																		20	3										23
43																			1		2								3
44																			1		7	1							9
45																				3									3
46																	1			7	2	1							11
47																			1										1
48																2				2									4
49																			1	14	14	22	13						64
50																					2	2		12					16
51																	26	15											41
52																			6		8								14
53																			1										1
54																				138									138
55																			14										14
56																		2											2
57																		15	19										34
58																	8												8
59																			2	91									93
60																		10											10
61																		19	17		3								39
62																			1										1
63																		3	1	1	2								7
64																											11		11
65																						4							4
66																					2								2
67																				23	66		22						111
68																					3								3
69																								4			4		8
70																							9	10					19
71																											1		1
72																						2		14					16
73																						5							5
74																						2	32		17	6		3	60
75																									3				3
76																									4	2			6
Total	4	3	2	54	46	4	6	21	15	2	17	85	69	90	106	142	122	76	121	183	319	143	49	89	40	24	8	16	3	1,859

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